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TRANSACTIONS

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"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

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THE FISH AND FISHERIES OF NEW ZEALAND

By Professor Edward E. Prince, LL.D., D.Sc.,
Dominion Commissioner of Fisheries, Ottawa.

INTRODUCTION.

New Zealand is a land of contrasts. Almost everything to which an American or European is accustomed is there reversed. Midsummer there is midwinter here. The northern parts are warm, almost tropical, while the cold increases further south, and Stewart Island at the southern extremity of the Dominion, has a climate as cold as Scotland. The most characteristic birds are practically wingless, and do not fly. The typical forest trees do not shed their leaves, and the luxuriant bush and the extensive plains of New Zealand, have never had any four-footed animals living upon them until introduced by the white man. The fisheries are no exception, and while the waters of New Zealand are prolific in fish, the most familiar and important food fish are totally absent, no cod, haddock, herring or true mackerel being found there.

RESEMBLANCE BETWEEN NEW ZEALAND AND MEDITERRANEAN FISH.

The latitude being between the 34th and 45th South parallels, the climatic conditions resemble those of Spain, or Portugal, or the southern part of Italy, and the typical fish recall in many ways, those familiar in the Mediterranean, and sold in the markets of Naples, Messina, or Lisbon.

SURVEY OF NEW ZEALAND FISHERIES IN 1914.

It was my privilege two years ago to make a survey of the fresh-water and sea fisheries of New Zealand, at the request of the Government of that Dominion. My

inspection was very complete, as I had all facilities afforded by the authorities for visiting every locality where fish occurred, and as very favorable weather prevailed during my lengthened cruises, I was able to make a complete survey in the five or six months allotted to the task.

I commenced my survey in April, the beginning of the New Zealand winter, and continued until the advent of spring, in the month of September. The beautiful government cruiser "Hinemoa," under command of the accomplished Captain Bollons, was used during my dredging, otter-trawling, drift-net and other experiments, and as Chief Inspector L. F. Ayson accompanied me, I had an unusual opportunity of making a full investigation of the fishery resources of New Zealand.

SCENERY.

It is not necessary to refer at length to the character of the country, for the scenic beauty of "Maoriland" is famous all over the world. Her snow-capped mountain ranges, running like a backbone through the whole country, and the vast glaciers and lofty peaks, are not excelled by the Swiss Alps, or by the Rocky Mountains of this continent. The fjords of the southwest coast are unexcelled for magnificent grandeur and tropical forest luxuriance, while the hot springs, geysers, and other volcanic phenomena are more wonderful and extensive than in any other part of the world.

From a fishery point of view the sheltered bays and romantic straits and extensive inshore fishing banks, are of the highest importance, while the picturesque lakes of which the larger in size exceed twenty in number, the swift flowing rivers, more than one hundred of them, provide the most favorable conditions for great and productive fisheries, and the scenery and the fertility associated with these waters, recall in many ways, the fishery conditions of Japan.

AREA.

The two main islands, with Stewart Island at the southern extermity, embrace an area of 103,581 square miles, and extend a length of about 1,000 miles, with a breadth varying from fifty to two hundred miles. The coast line, 4,330 miles, is indented by beautiful bays like the Bay of Plenty, Hawkes Bay, Golden Bay and Hauraki Gulf, etc., and the picturesque shores are washed by the open South Pacific Ocean on the east, and deep Tasman Sea on the west.

AREA OF AVAILABLE FISHING LIMITS.

I estimated the inshore waters, 10 to 30 fathoms deep, at not less than 20,000 square miles, while about 25,000 square miles range from 40 to 50 fathoms in depth, and outside these (10 to 20 miles from shore) the depth descends to 300 or 400 fathoms, and greater depths lie beyond. The inland lakes are famous for their exquisite beauty, the shores in most cases being backed by lofty mountains with forests of tree-ferns and giant kauri and totara trees, the beautiful red pine, rata and various birches or beeches. Some of these lakes are of considerable area, Taupo for example, 250 square miles, Te Anau, 132 square miles; Lake Wakatip, 120 square miles; the last descending to a depth of 1,300 feet in some places. The total area of the lakes including rivers, some of which like the Clutha or Molyneux are 150 miles long, approaches 15,000 square miles or about one-sixth of the area of the Great Lakes of this continent.

VALUE OF FISHERIES; NUMBER OF FISHERMEN, ETC.

The fisheries have not been developed to any great extent, the population of New Zealand being small (1,115,000), and the demand for fish limited, while the main outside markets have been those of Australia, to which considerable exports of fish have been made.

1,500 or 1,600 persons are engaged directly in fishing or handling fish, about 1,000 of these being actual fishermen, while the annual value of fish caught probably does not exceed $500,000, including about $200,000 worth exported, mainly to Australia.

It is remarkable that New Zealand imports, annually, fish to the value of $540,000, mainly from the British Isles, notwithstanding that her own waters are so productive, and many species of excellent fish are abundant.

NUMBER OF SPECIES OF FISH.

Over three hundred species of teleostean fishes have been described in New Zealand, but of these not more than thirty-five are regarded as food fishes, and even some of these are not in public favor, although in many cases exceedingly good table-fish.

BLUE COD OF IMPORTANCE ECONOMICALLY.

They belong very largely to the rough scaled spiny-finned kinds of which the red snapper and groper are types. Amongst the more important species must be counted the blue cod, *Parapercis colias*, Forster, which is in great favor, and though not a large species, is regarded perhaps as the best of the food fishes in New Zealand seas. There is a large domestic demand for it and cured and smoked it is exported in considerable quantities to Australia. Captain Cook called it the "coal" fish, and remarked on its abundance, and it is still very plentiful, and of widespread occurrence all along the coast, especially on precipitous rocky shores. They are caught in from 10 to 15 fathoms depth, and range from one up to five pounds, reaching ten pounds weight off D'Urville Island, Cook Straits, where the water is deep. Not at all resembling cod, and not belonging to the cod family, it is curious how it has acquired the name, especially as its colors are very brilliant; often a dark green along the sides marbled with brown and a patch of green over each eye, while the under side is

greyish white. The fins are grey spotted with brown, and the dorsal fin, the first five rays of which are sharp spines, runs the whole length of the back. As already stated it is a delicious fish when smoked, but when very slightly salted, it is much in favor, and is of unusually excellent table qualities. Hardly less important is the gigantic Hapuka or Groper (*Polyprion oxygeneios*, Bloch) which is really a hugh sea-bass or sea-perch, and ranges from 40 to 50 or even 100 pounds in weight. It belongs to the order Serranidæ, and frequents depths of 60 to 90 fathoms, or even still deeper water. It is usually caught by baited hand-lines, but will frequently not take the bait in July, when the fishermen state that it is spawning. A still larger species occurs at greater depths outside, and is called *P. Americanus.* The gropers are, on account of their firm, white flesh, and their large size, exceptionally important from a commercial standpoint.

The Moki, which is one of the Latrididæ, though less esteemed than the groper, is an excellent food fish, and when smoked, is equal to finnan haddie. It is a handsome perch-like fish ranging from 2 to 19 pounds in weight, and frequents water 10 to 40 fathoms deep. There are two species, the more abundant being *Latris ciliaris*, Forster, which sometimes completely fills the fishermen's nets; but another species, *Latris lineatus,* Forster, is much larger, and specimens three feet long have been taken off Tairoa Head. Both are handsome perch-like fishes, silvery on the sides, and lead-colored with a golden sheen on the back.

THE SNAPPER A VALUED SPECIES.

One of the most familiar food fishes, and generally esteemed, is the snapper, *Pagrosomus auratus,* Forster. It is an active, handsome fish, and typical of the family Sparidæ, with a high back, markedly forked tail, serrated brilliant scales, and of a delicate rose color, fading into grey along the sides. The snapper is very wide-

spread, abundant in the north and extending even as far south and west as Dusky Sound. It is plentiful near Auckland and Poverty Bay, especially around the weird eternally-smoking White Island. As many as 2,000 snappers are often taken in a single haul. On hotel bills of fare, in New Zealand, this red snapper is a favorite item, and the firm white flesh, and delicate, if not very marked flavor, cause them to rank high as food fishes.

CONGER, LING AND OTHER FISH WASTED.

Fine conger eels, sometimes of a striking yellow color, frequent the offshore waters, and specimens reaching a length of 6 or 7 feet are quite common. The species is *Leptocephalus conger,* Forster, and it is scaleless, but has very firm and palatable flesh. The conger eel is not eaten in New Zealand, and quantities are dumped overboard each season by the fishermen, and as on this continent are thus wasted; nor does the ling, *Genypterus blacodes,* one of the Ophidiidæ, fare better. Ling range from 10 to 20 pounds or over, and are common on the shores of South Island, but are not eaten, though the flaky flesh is white and salts well.

KINGFISH OR SO-CALLED BARRACOUTA.

The savage looking so-called Barracouta or Snoek, *Thyrsites atun,* Euphrasen, is abundant, three feet long and five pounds and over, in weight. Split and smoked, it sells readily, and large quantities are taken by the fishermen. Its abundance may be judged from the fact that two men will take 250 to 500 in three or four hours fishing. The name Barracouta, is sometimes given to two other fish, namely the king-fish, of the South Island, *Rexea furcifera,* Waite, and the fine silvery kingfish of North Island, *Seriola lalandii,* really the Yellow Tail or Amber Fish of Florida and the Carolinas. The former, which belongs to the Trichiuridæ, exposes two formidable canines on the projecting lower jaw, even when the mouth is closed, and it has thus quite a fero-

cious appearance. The latter, one of the Carangidæ, is remarkable for the size it may reach, some specimens being 40 pounds weight and 4 feet long; but usually they are smaller, 6 to 10 pounds in weight. Both of these fish are fine food-fish, but do not keep well in a fresh state. Great quantities of the South Island king-fish are split, salted and smoked for home and export trade.

TREVALLY AND OTHER KINDS.

Two fishes common in New Zealand waters are called Trevally, one, *Seriolella brama,* Günther, and the silvery sea-bream generally called the Warehou. The former attains a length of two or three feet (12 to 14 pounds weight) but those of smaller size are better flavored; and the sea bream, *Caranx platessa,* which occurs everywhere, often in enormous numbers ranges from 2 to 3 pounds in weight. The latter is a typical Caranx, whereas the Warehou belongs to the family Stromateidæ, to which the "dollar" fish and other familiar kinds belong. A very handsome species which recalls the salmon on account of its elegant shape and active rapidity in the water, is the Kahawai, *Arripis trutta,* Forster, 3 to 7 pounds or more in weight, greenish grey on the back with lead blue spots, white sides, and a dark elegantly forked tail. It occasionally ascends some of the northern rivers for 30 or 40 miles, and it is not surprising that the name "native salmon" has been given to it, though it belongs to the family Sciaenidæ, under which the sea-drum and many tropical and sub-tropical fishes are ranged. One familiar table-fish has a widespread range, namely the Terakihi (*Cheilodactylus macropterus*), a small elegant bass-like fish ½ to 1½ pounds in weight, though it may reach 6 to 7 pounds; but it is not very highly esteemed by epicures.

FROST FISH (LEPIDOPUS).

Of the less abundant fish, mention must be made of the remarkable Trichiurid, the frost fish or hiku, *Lepidopus caudatus,* Euph., 4½ to 5 feet in length, for

which, however, no regular fishing can be carried on, on account of its erratic and peculiar mode of occurrence.

Each season quantities are taken after frosty nights in winter, being cast upon certain flat beaches, and writhing like silvery snakes, 4 to 5 feet long, may be captured by hand, hundreds at a time. The flesh does not keep very well, but it sells at high prices in the local markets, for it is regarded as one of the most delicious fishes in New Zealand waters. The cause of this suicidal tendency is a mystery. Possibly they are male fish, affected seasonally, as has been found to be the case with the pollock, and other marine species.

HAKE, RED COD AND OTHER KINDS.

The esteemed John Dory, *Zeus faber,* the hake, *Merluccius gayi,* sometimes called whiting, the mackerel, *Scomber pneumatophorus,* the sword fish, and a species of pilchard, are native to New Zealand waters. A small herring not to be compared with the herring of northern seas, also occurs. The small red cod, *Physiculus bachus,* Forster, 12 to 20 inches long and 2 to 5 pounds in weight, is very widespread, but vast quantities are thrown away by the fishermen because there is little or no demand for them. The fish is somewhat insipid, but it could be readily utilized on a large scale, for when smoked, its qualities are much improved, and it is one of the most plentiful of inshore fishes. They disappear for a season or two unaccountably, after one or two seasons of abundance.

WASTE OF FINE GURNARDS.

Hardly less abundant is the gurnard (*Prionotus*), of which three kinds occur, the commonest is of a brilliant red color with fine, firm flesh, but so little desired by the public that tens of thousands caught by the fishermen are thrown back into the sea. It is not inferior to the esteemed gurnards of Europe, but is usually wasted in large quantities each season.

FLAT FISHES OF VARIOUS SPECIES.

Of soles and flat fishes, there are many species. The New Zealand sole, *Peltorhamphus,* is very highly esteemed, while the so-called turbot, *Ammotretes,* and the brill and the lemon sole (*Pelotretis*) are very common and of very good quality, but the Megrim (*Caulopsetta*) and Sand flounder (*Rhombus solea*) though extremely abundant, are very much inferior in quality.

THE ESTEEMED MULLET.

Mention must be made of the Mullet (*Mugil*) which has been caught in large quantities in the northern estuaries, 150 dozen being taken at one "set" on the Kaipara River. It has also been canned, and like all the Mullet family, is a most delicate and delicious fish.

A curious Chimæroid fish is surprisingly plentiful. It is the Elephant Fish (*Callorhynchus*) and most grotesque in shape, though handsome, owing to its bright silvery coloration. The flesh is white and firm and might be utilized if public prejudice against the sharks and their congeners could be overcome.

LOBSTERS, OYSTERS, ETC.

Of the crustacea, the reddish spiny lobster, *Jasus Edwardsii,* is extremely abundant, and may be captured in enormous quantities along the shores generally. The flesh is not quite so delicate in flavor as the true lobster, but as in Cape Colony, there is ample scope in New Zealand for a lobster canning industry, the spiny lobster being not only extremely plentiful, but of large size. It must be added that there is practically no claw meat in this species as the nipping claws are very small.

The oysters of New Zealand are very remarkable as one kind is dredged in fairly deep water and another kind, the delicious and delicate rock oyster, is found coating the rocks over large extents of the coast. This latter oyster, *Ostrea glomerata,* Gould, is cup-like in form, and

of extremely delicate flavor, but it must be fished for with a hammer and chisel as the bunches of these shellfish adhere firmly to the rocks, mainly in the northern waters of New Zealand. Deep-sea oysters occur especially in the Foveaux Straits in 15 or 20 fathoms, and are of considerable size and exceedingly good quality, though not equal to the rock oyster. They are scientifically called *Ostrea angasi,* Sowerby.

NEW ZEALAND CLAMS ARE SUPERIOR.

A most excellent clam occurs, especially on certain shores of the North Island, called the toheroa, a very delicate and delicious soup being made from these shellfish. Quite a fishing industry has been developed on the clam beds, which occur over considerable areas of the eastern shores.

A few words are necessary in regard to the fresh-water fish which were almost absent from the rivers and inland waters before the white man settled in New Zealand. The native fresh-water species are very few, and not to be compared with the fresh-water species of North America.

EELS, WHITE-BAIT AND OTHER NATIVE RIVER FISH.

Native eels (*Anguilla*) are extremely abundant, and indeed are a menace to superior fish, but the white-bait or small Inunga, is extremely abundant, and much esteemed as a delicacy on the table.* There are several species of so-called native trout or Kokopu (*Galaxias*), and they afford a small amount of sport, but they have been altogether overshadowed by the introduced species, namely the rainbow trout, European brown trout and the Pacific cutthroat trout.

*Locally stated to be the young of the New Zealand Smelt (*Retropinna*) and the so-called native trout (*Galaxias*), but the specimens examined by me were the young of the latter (*Galaxias*).

INTRODUCED TROUT, A GREAT SUCCESS.

These have established themselves thoroughly in New Zealand, and all of them reach a large size. Fish 5 to 7 or 8 pounds are quite common, and specimens have been taken in numbers weighing 25 to even 27 pounds. No fishing in the world can excel the trout fishing in such lakes as Taupo, Rotorua and Wakatipu. The Atlantic salmon, though repeated attempts have been made to establish it, has not been a success. A small proportion seems to have survived, and there are records of grilse being caught around the shores, but the introduction of this species must be regarded as unsuccessful.

QUINNAT SALMON ACCLIMATIZED.

It is otherwise with the spring salmon or quinnat of the Pacific Coast of America. This fine Salmonoid is now thoroughly established in several New Zealand rivers, and the fish spawn regularly each season, so that there is a great future in store for the Pacific species of salmon. Great credit is due to the head of the Fisheries Department, Wellington (Mr. L. F. Ayson), for his zealous and successful fish-culture work. The Acclimatization Societies too merit a meed of praise for their splendid efforts with fish and game.

WHALES, SEALS, ETC.

A closing word must be said about the wonderful whaling and sealing industries which have been carried on for a long period in New Zealand waters. Whales still occur and fur seals are also found, but both are in such diminished numbers, that their total extinction in the near future is to be feared. It is hoped that protective measures may be effectively enforced as the New Zealand Government has shown itself willing to carry out a wise policy in regard to certain native animals. It has extended its protective legislation to marine creatures in a unique manner.

"PELORUS JACK."

It is well known that a fine specimen of Risso's grampus, known the world over as "Pelorus Jack" was protected by special legislative enactment. This creature 14 feet long frequented Pelorus Sound in Cook Straits for over fifty years, and was accustomed to meet and accompany steamers, navigating through the sound. Tourists always looked out for "Pelorus Jack" and under parliamentary protection it continued unharmed until recently when it ceased to appear, and is believed to have been criminally killed, or to have died from old age.

PROMISING FUTURE FOR NEW ZEALAND FISHERIES.

The varied fresh-water and marine products of New Zealand, are such that a great future lies before the fishing industries, if they are developed and properly conserved. Fishing can be carried on all the year round practically, owing to the fact that there is no winter season in New Zealand and the hardships of winter fishing are unknown, though stormy weather, especially on the west coast is often a serious interruption. No systematic prosecution of the fishing industry has really been carried on on an adequate scale, and the limited markets and small local demand may partly account for this, though complaints are common in New Zealand that the people cannot get supplies of their own fish at reasonable rates. There is no reason why canning and curing industries should not be carried on upon a large scale, and New Zealand fishery products shipped to all parts of the world. Instead of importing preserved fish in large quantities as at present, New Zealand should export extensively. The government has indeed had in view a great scheme of fishery development, and my own report made in 1914, will no doubt offer much guidance in this future development.

PACIFIC HALIBUT FISHERY DECLINING

By John N. Cobb, *Seattle, Wash.*

For the past two years the condition of the halibut fishery of the Pacific Coast has been a cause for concern on the part of those interested in its preservation. While the total yearly catch of halibut has been steadily on the increase for some years, thus apparently indicating a healthy condition, yet the reverse is really the case, the increase in catch being far from proportionate to the increase in the fleets operating, while it has been necessary to extend widely the range covered and to increase vastly the amount of gear used in order to secure this catch, thus showing that the reserve or capital stock of fish is being steadily depleted.

In showing the present statistical condition of the industry as compared with some years ago I have selected the years 1904 and 1914, a period during which the greatest changes and expansion in the industry have occurred, and have restricted the data to the Puget Sound fleet, which in both years comprised the greater part of the vessels working on the halibut banks, and the one for which the data are most complete. The catch per dory will be used for comparison as being the one most easily fixed.

In 1904, the Puget Sound fleet comprised 35 sailing schooners, with a net tonnage of 645, and operating 78 dories; 1 power schooner, with a net tonnage of 14, and operating 3 dories; and 3 steamers, with a net tonnage of 108, and operating 18 dories; making a grand total of 39 vessels with a net tonnage of 767, and operating 99 dories. This gives an average of 19.67 net tons to the vessel, and an average of 2.5 dories to the vessel. The catch of halibut by this fleet in 1904 amounted to 11,774,000 pounds, and this divided by 99, the total number or dories, gives an average per dory of 118,929 pounds. This catch brought the fishermen an average of nearly 3 cents per pound for first grade fish.

In 1914, the Puget Sound fleet comprised 90 power vessels, with a total net tonnage of 2,635, and operating 361 dories; and 7 steamers, with a total net tonnage of 1,118, and operating 92 dories; making a grand total for the fleet of 97 vessels, with a total net tonnage of 3,753, and operating 453 dories. This gives an average of 38.69 net tons to the vessel as compared with 19.67 in 1904, a gain in size of 19.03 net tons per vessel for 1914. An average of 4.67 dories to the vessel is also shown, an increase of 2.17 over 1904, when the average number of dories to the vessel was 2.5. The catch of halibut by this fleet in 1914 amounted to 43,305,805 pounds, and this divided by 453, the total number of dories, gives an average per dory of 95,597 pounds. The average price per pound of first grade fish received by the fishermen for this catch amounted to 4.7 cents.

The average catch per dory in 1904 was 118,929 pounds, while the average per dory in 1914 was 95,597 pounds, a decrease per dory in the latter year as compared with 1904 of 23,332 pounds, or about 20 per cent.

In considering this decrease per dory since 1904, the conditions in the former year, and for some little time after, should be taken into consideration. In 1904, there was a limited, but growing, demand for halibut, and as the fleet was more than able to supply this demand but few of the vessels were operated throughout the year. Of the fleet of 35 sailing and 1 power schooners, 11 operated only on the nearby banks, thus tying up or engaging in other business during a portion of the year, while 7 of the remainder fished for halibut in Alaska alone, presumably engaging in other fishing operations or acting as run boats in the salmon industry the rest of the year. Had the whole fleet engaged continuously in the industry throughout the year, as was the case in 1914, the average per dory in 1904 would have been vastly larger than it really was, thus making the decrease since much more pronounced than the figures indicate.

Twelve years ago the fleet was composed almost wholly of small sailing vessels, nearly all of which had

their headquarters on Puget Sound, and which operated during the greater part of the year on banks lying within 400 miles of Seattle. During the inclement weather of late fall, winter and early spring a portion of these vessels made their headquarters in Southeast Alaska and fished on the banks in the protected waters of that region, shipping their catch down on the regular steamship lines.

Today the sailing vessel is unknown in the halibut fishery, having been superseded by vessels with twice the carrying capacity of those formerly engaged, the increase in size permitting them to carry double the number of fishermen and dories. These vessels are all powered with gas engines. Instead of getting its catch within easy steaming radius of Seattle, the fleet now fishes mainly on the Alaska off-shore banks, ranging from 800 to 2,000 nautical miles from Seattle. A greater amount of gear to the dory is set at present than was the case twelve years ago, while the introduction, several years ago, of the method of long-line fishing directly from the deck of the vessel permits fishing now in weather when it would not be safe to launch a dory.

Closed Season Proposed:—About two years ago, in the Pacific Fisherman, a journal devoted to the interests of the Pacific Coast fisheries, I called attention to the condition of the halibut fishery, and suggested that a closed season, say from November 15 to February 15, be established. Since then the demand for a protective measure of this sort has been steadily growing. About six months ago the Department of Naval Service of Canada, which department has charge of fishery matters in the Dominion, addressed inquiries to its own halibut fishermen and dealers, endeavoring to learn the exact status of affairs, and inquiring as to whether they favored a closed season. I am informed, through apparently reliable sources, that the large majority of the responses were favorable to the idea of a closed season of from one to three months.

The ideal time for a closed season is when the fish in question are spawning, and, fortunately, in the case of the halibut this comes during the winter months, when

fishing is usually prosecuted at the greatest disadvantage. W. F. Thompson, in his Preliminary Report on the Life-History of the Halibut (Rep. B. C. Com'r of Fisheries for 1914, pp. 76-99), as a result of his study of the Pacific halibut, says, "It may be stated with confidence that the halibut breeds on this coast between the middle of December and the last of April or the middle of May." This, he states, may be subject to some variation, but is practically correct.

On February 21 a bill was introduced in Congress, which seeks to establish a closed season on the catching of halibut on the banks in the Pacific Ocean during the months of December and January, and prohibiting, under penalties, any violation of the act; also setting aside a certain area in Southeast Alaska as a nursery for halibut and prohibiting fishing in this restricted area at any time.

As Canadian vessels also fish on these same banks, and a closed season would not be of much value unless it included both nations, the act provides that it shall not take effect until Canada has enacted concurrent or essentially similar regulations governing its own people and vessels.

The fact that the halibut attains maturity slowly as compared with the salmons, for instance, makes it especially necessary that it should have some protection. Thompson's investigations (loc. cit., p. 93), show that "there are but relatively few halibut which mature during the eighth year of their lives, the chances being one in twenty-five against obtaining such a one, and there are fish still immature in the fifteenth year of their age. The eighth is, however, the age of a large proportion of the fish in Hecate Strait at the time of capture. In Hecate Strait but 14 per cent. of the female fish caught had completed their twelfth year and but 5 per cent. their sixteenth year. Off Kodiak Island 31 per cent. were beyond the twelfth year and 12 per cent. beyond the sixteenth. This increased percentage of mature fish may, of course, be characteristic of the banks which have been

less intensively fished. However this may be, it is evident that a large majority of fish caught do not reach maturity."

So far as published, his investigations show that the fish from Hecate Strait and off Kodiak Island attain maturity at twelve years of age. He also states that he believes the maximum age attained by the halibut to be about twenty-five years.

The above shows plainly that a large proportion of the fish caught are immature, i. e., fish which have never spawned. As the halibut roe contains about 2,000,000 eggs as compared with say about 2,000 eggs in a salmon roe, this superabundance of eggs deposited by the halibut counterbalances in some degree the late maturity of the species. It is, plain, however, that the first object of the authorities should be so to protect the halibut that a larger proportion may attain to maturity, and the first step should be to prevent the catching of small halibut, knows as "chicken" halibut.

Early History of the Fishery:—The present extensive halibut fisheries of the Pacific owe their inception to the publication in 1886 of a series of very optimistic letters in the Cape Ann Advertiser, of Gloucester, Mass. The enterprising spirit of the New England fishermen prompted them to consider the matter favorably, particularly as they knew from the most reliable sources that halibut were abundant off Cape Flattery at certain seasons. The native fishermen had fished here for their own use (the surplus being sold to the whites living on the shores of Puget Sound) for many years previous.

The pelagic fur-seal fishery, which was then lawful and quite profitable, was another strong inducement for the eastern fishermen to make the venture of sailing "around the Horn," for some believed that this offered unusual opportunities for financial success, while they thought the period between sealing seasons might be profitably utilized by engaging in halibut fishing. The men who entered upon this experiment were among the most skillful, daring and adventurous of their class and,

so far as catching fish was concerned, none could be found better fitted for the work.

In the fall and early winter of 1887, three schooners sailed from Massachusetts for Puget Sound. These were the Mollie Adams and the Edward E. Webster, of Gloucester, and the Oscar and Hattie, of Swampscott. The two former were owned by Capt. Sol. Jacobs, who had achieved fame as a mackerel fisherman, and who, after dispatching his vessels, crossed the continent in time to make the necessary business arrangements, pending their arrival. The Mollie Adams made a good passage and reached her destination without mishap; but the Webster met with an accident to her spars before rounding the Horn, put into Montevideo for repairs, was delayed, and finally arrived on the west coast late in the season.

The Oscar and Hattie reached Puget Sound some time later than the Adams, but in time to engage in the halibut fishery, upon which she entered, making her headquarters at Port Townsend. Owing to the want of a suitable market, and to the fact that the schooner had to go to Tacoma to ship her catch east, the fishery from this place was followed with loss rather than profit. The Oscar and Hattie carried 6 dories and a crew of 14 men.

About two-thirds of the catch was sold fresh and the remainder was fletched. The result of the season's work in 1888 was 240,000 pounds of fresh and fletched fish, with a value (at the prices paid the fishermen) of $7,600. The average price received for fresh halibut was 3 cents per pound, and for salt fish 3½ cents per pound.

The catch shipped east by the Oscar and Hattie was the first shipment so made, and it went forward by the Northern Pacific railroad. The ice used cost $22.50 per ton(more than five times the present cost of ice), and the high freight rates charged by the railroad took all the profit of the shipment.

On July 24, 1888, the schooner Mollie Adams left Seattle, bound north on a fletched halibut trip, the first one of its kind that had been undertaken on the Pacific Coast.

But few halibut were captured until the schooner arrived off the southern extremity of the Queen Charlotte Islands, where they were found in great abundance and of larger size than on the grounds off Cape Flattery. A few of those taken were estimated to weigh over 300 pounds each. About half of the number obtained were large enough for fletching, the remainder being used as bait or thrown away. The fishing was carried on in depths of only 30 to 45 fathoms.

On the morning of September 8, the Adams having "wet" all her salt, started for home with 150,000 pounds of fish. In the meantime, after a lot of trouble, her owner, Captain Jacobs, had arranged for a rate of $1.25 per hundred pounds for the transportation of the fish across the continent to Gloucester. After deducting expenses the members of the crew received $175 each, or at the rate of nine dollars a day for nineteen days' fishing.

It was soon found that Port Townsend was too remote from railroads for shipping purposes and in a very short time Seattle became the headquarters of the schooner fleet. The New England Fish Company, an American firm, soon after located at Vancouver, British Columbia, while the International Fisheries Company, located at Tacoma, Wash., put on fleets of steam vessels, and have since been important factors in the development of the industry.

Fishing Banks:—For a few years the fishing for the fresh markets was confined to Flattery Bank, located off Cape Flattery, at the mouth of the Straits of Juan de Fuca, and extending from close in shore to some twelve or fifteen miles off the cape, in depths of water ranging from 35 to 75 fathoms. From early in the spring until the middle of June halibut can be obtained on these grounds in paying quantities, but later in the season dogfish and sharks strike in, driving nearly all the edible fishes away.

The steamers early devoted their attention to the banks which had been discovered in Hecate Strait and Dixon Entrance. Later good grounds were found in the neigh-

borhood of Cape Scott, on the northern end of Vancouver Island, British Columbia. Another, and for some years, one of the most prolific grounds yet discovered, lies off the northern end of Graham Island, between Rose Spit and North Island. All along this shore, for a distance of sixty miles, good fishing was found in from 25 to 40 fathoms for a number of years.

The chief objection to most of these banks was that they were in the vicinity of islands belonging to Canada, which government, for some years, harassed our fishermen in every way possible, and as a result of this condition of affairs and the gradual exhaustion of the Canadian banks, our fishermen began seeking new banks in Alaskan waters. Small banks lying in what are known as the "protected waters," i. e., the bays, straits and sounds dividing the numerous islands forming the greater part of Southeast Alaska, had been fished by both whites and indians for some years, but they were not prolific enough to justify the larger vessels resorting to them. During the winter of 1909-10 several of the steamers prospected the open waters between Cape Muzon and Sitka, with the result that halibut were found in great abundance throughout the greater part of this area. Off Forrester Island seemed to be the center of greatest abundance. Here an average depth of 80 fathoms is found for about four miles from shore; a little farther out it deepens to 150 fathoms. The first few cargoes from here averaged fifteen pounds to the fish, but the average soon dropped to fourteen pounds.

As these banks became depleted the fleet gradually worked its way north and west, first off Sitka, then on the Fairweather ground, then off Prince William Sound, and at the present time some of the vessels fish as far west as Portlock bank, near Kodiak Island.

It is probable that ultimately the larger vessels will be compelled to fish as far west as Unimak Pass. It is known that halibut are to be found, supposedly in limited numbers, on the famous cod banks in the section between Kodiak Island and Unimak Pass.

THE NEW ENGLAND FISHERIES, 1915

BY FREDERICK F. DIMICK, *Boston, Mass.*

The following notes from the Annual Report of the Boston Fish Bureau will be found of interest to our members:

Reviewing the fisheries of the year probably the most sailent feature has been the improvement in the mackerel fishery. The total catch of these fish on the northeastern coast of North America amounted to 138,466 bbls.—96,564 bbls. fresh, and 41,902 bbls. salt.

Among the impressive events of the year might be mentioned the introduction of the tilefish by the Bureau of Fisheries. The efforts of the Bureau to popularize this fish has met with splendid success. It seems almost incredible that fish of so much value covering an area of 70,000 square miles, 50 to 75 miles south of Nantucket, should not have been marketed before.

A subject coming before Congress is the destruction of the dogfish. These fish destroy the food fish, and hamper the operations of the fishermen. The amount of fish destroyed by man is but a drop in the bucket compared with the amount consumed by dogfish and other predaceous fish.

Too much importance cannot be laid on care in the preparation of fish for market whether fresh or salt. The new law in regard to the inspection of fish that went into effect in Canada on the first day of May, the object of which is to bring into general use a strong barrel of a standard size for marketing pickled fish, to raise the standard of curing and grading fish, should be a benefit to trade.

A bill has been introduced into Congress to limit the time that fish can be held in cold storage to three months, and contains other pernicious regulations. If this bill becomes a law it will increase the cost of living, and cripple the fishing industry.

FRESH FISH.

On March 30, 1916, the business at the Boston Fish Pier, where the fresh fish business of the city is conducted will have been in operation for two years during which time substantial progress has been made. The

buildings in this part of Boston that comprise the Boston Fish Pier constitute a city by itself.

Groundfish:—The catch by the fleet that makes this port its headquarters shows an increase. In the spring and summer the fleet landed good catches of haddock. Codfish, however, have been in comparatively light supply. Receipts were decreased in the fall by a strike of the fishermen of the steam trawlers.

The fishing fleet numbered about the same as in the previous year, 330, of which 167 were sailing vessels, 13 steam otter-trawlers, and 150 boats of various kinds.

The catch of the Gloucester gill netters, that is largely received here, amounted to 7,400,000 lbs. compared with 8,500,000 in the previous year.

Prices of haddock, by months, ex vessel, have ranged about as follows: (Dollars per 100 lbs.)

	High	Low		High	Low
Jan.	$8.00	$2.00	July	$4.10	$1.10
June	5.50	1.25	Dec.	8.50	2.10
May	7.00	.90	Nov.	8.00	3.25
April	4.50	1.00	Oct.	6.90	1.50
March	6.50	1.25	Sept.	6.00	1.25
Feb.	8.00	2.00	Aug.	4.75	1.15

Some of the best stocks were:

Vessel	Captain	Stock
Pontiac	Ernest Parsons	$50,735
A. Piatt Andrew	Wallace Bruce	46,124
Commonwealth	Frank Watts	43,709
Mary C. Santos	Manuel C. Santos	43,000
Elizabeth W. Nunan	Frank Nunan	36,172
Natalie Hammond	Chas. Colson	32,970
Progress	Antonio King	32,000
Mary P. Goulart	A. Goulart	24,800

Mackerel:—The southern mackerel fleet got an early start, the first vessel sailing sixteen days earlier than the previous year.

The first trip of mackerel was landed April 9, schooner Rob Roy, at Lewes, Del., 3,240 mixed mackerel, caught 100 miles east by south from Cape Henlopen in 40 fathoms. First arrival at Chincoteague April 16; first catch at Chatham, April 20; at Seaconnet, April 20; near Yarmouth, N. S., May 14; at New York, from Carolina trap, March 24.

The first Cape Shore arrivals from the fleet were on June 7th, ten vessels having an aggregate of 430,000 fresh mackerel. Sales were made at 15 to 16 cents each for large, 8 to 10 for medium, and 4 to 6 for small. The first arrival the previous year was on June 8th, and sold at 17½ cents for large, and 8 cents medium.

The total receipts from Cape Shore were 781,000 fish, compared with 503,000 the previous year.

The total catch of fresh mackerel by the fleet amounted to 71,564 bbls. against 68,582 the previous season.

Foreign receipts of fresh mackerel show an increase of about seventy-five per cent.

Some of the best stocks by mackerel seiners were:

Vessel	Captain	Stock
Str. Lois H. Corkhum	William Corkhum	$33,200
Lottie G. Merchant	Ralph Webber	33,000
Monarch	John Seavey	28,884
Marguerite Haskins	Reuben Cameron	28,809
Arthur James	John Matheson	26,959
Rob Roy	Lemuel Firth	26,158

Herring:—The catch along the shore was a moderate one. The first seine herring were taken at Gloucester, April 25th. The first herring bait at the same place, April 1, 500 fish.

Swordfish:—Swordfish were in good supply during the season. The fleet comprised 42 sail, and fished mostly to the eastward but experienced much bad weather.

On July 20th there were 17 arrivals at the Boston Fish Pier having 1,126 fish from Georges, probably the largest number of swordfish ever landed in one day. Sales at 8 cents per pound.

Schooner Gladys B. Simmins, from Georges, the first arrival, June 21, twenty-six fish, sold at 20 cents per lb.; the first the previous year, schooner Virginia, 16 fish, June 24, sold at 21½ cents per pound.

Schooner Albert D. Willard, Capt. Fred Bickford, is high line of the swordfish fleet, having stocked $6,800, the crew sharing $270. In four trips this vessel landed 278 fish.

Halibut:—About 30 vessels engaged in this branch of fishing on the Atlantic coast, and made good stocks.

The catch on the Pacific coast was 33,133,313 lbs., compared with 41,825,575 the previous year. The average price paid the vessel this year was 5.7 per lb.; in 1914, 4.7.

A closed season in the halibut fishery is being agitated on the Pacific coast from November 15 to February 15, and it is reported that the fishermen are largely in favor of it with the hope of putting the industry on a more profitable basis, and conserving the supply for future fishing.

Some of the best stocks of vessels on the Atlantic coast were:

Vessel	Captain	Stock
Richard	Augustus G. Hall	$30,500
Rex	Robert Wharton	29,839

Tilefish:—The schooner Hortense that arrived at Boston Fish Pier, December 23, with 16,000 lbs. of tilefish, had the first trip of these fish ever brought into Boston by a fishing vessel fitted out especially for that kind of fishing. They sold at 4c per lb. The fish varied in size from 8 to 40 lbs. each, and were caught 90 miles southeast of New York on the western slope of the Gulf Stream.

FROZEN FISH.

Most all kinds of frozen fish have been in good supply, and large quantities have gone into consumption, including mackerel, salmon, halibut, herring, butterfish, haddock, whiting, etc. During periods of scarcity of fresh fish caused by bad weather it has been most always possible to obtain frozen fish of fine quality.

Herring:—Shore frozen herring have been in fair supply. Large shore herring from Maine of fine quality have been received, and were in good demand, as they compare quite favorably with Newfoundland fish. Blueback herring have been in good supply.

Newfoundland herring were in light supply and sold at high prices. The receipts the winter of 1914-1915 amounted to 12,990 bbls. compared with 15,090 in the previous season.

Smelts:—This kind of frozen fish is in good demand during the winter months. The mild weather in the fall put off the fishing operations and receipts were late in coming from Canada. The fish are running of small size.

Mackerel:—Frozen mackerel have been in good supply. During the summer when mackerel were plenty on the shore considerable quantities were put into the freezers.

The fresh mackerel netters fished later in the season than usual this season which was unfavorable to the distribution of frozen fish.

Other Frozen Fish:—Squid and whiting have been in fair supply. Squid have been exported to Canada and Newfoundland where the catch of these fish was a failure. Whiting have been in fair supply. Salmon and halibut have been in good supply.

SHELL FISH.

The first shipments from Nova Scotia for the season were received December 19, 1915, 499 crates, and sold at $25.00 per crate. The first, the previous season were received December 21, 260½ crates, and sold at $25.00 per crate for large, and $15.00 for small.

Total foreign receipts of lobsters were 43,943 crates as compared with 22,741 the previous year.

The latest information of the lobster fisheries of the Atlantic coast, covering the year 1913, shows the total catch and value of lobsters, as follows:

	Pounds	Value
Maine	7,670,667	$1,525,776
New Hampshire	301,710	108,560
Maine	1,524,389	290,423
Rhode Island	1,283,056	197,960
Connecticut	724,435	131,767
New York	435,811	81,783
New Jersey	301,349	54,155
Delaware	25,600	4,398
Total	12,267,017	$2,394,822

SALT FISH.

Mackerel:—The production of salt mackerel of the world owing to the small amounts cured in Ireland and Norway was the lightest on record.

Our first receipts of salt mackerel of any consequence came from Cape Shore. Ten vessels arrived from there, June 7th, having a total of 1,462 bbls. They counted from 180 to 200 fish to a barrel and sales were made at $8.00 per barrel. The total catch of the Cape Shore fleet amounted to 3,400 bbls., and sold from $7.50 to $8.50 per bbl.; the previous year 2,775 bbls., and sold at from $9.00

to $10.00 per bbl. The Cape Shore fleet numbered 19 sail, compared with 31 the previous year.

When the market was glutted with fresh mackerel considerable were sold for salting. The shore fish were of desirable size, but early in the season the demand was light owing to the unsettled conditions caused by the war.

Shore mackerel sold in July ex vessel at from $9.00 to $14.00 per bbl.; in August from $14.00 to $14.50; September $15.00 to $17.00; October $17.50 to $19.00.

A small fleet went to the North Bay, but were unsuccessful owing to bad weather.

The catch at the Magdalen Islands was the best for five or six years, but at other points in Canada the production was light.

The amount salted in Ireland was light owing to the good demand in the English markets for fresh mackerel. A large portion of the Norwegian catch was also consumed fresh.

The catch of salt mackerel of the leading countries of the world, compared with 1914, were as follows:

	1915		1914	
United States	19,691	bbls.	15,521	bbls.
Canada	26,281	"	24,277	"
Ireland	6,915	"	30,830	"
N'rw'y and Sw'd'n	12,211	"	35,512	"
Total	65,098		106,140	

Codfish:—The feature of the codfish trade has been the unprecedented demand for fish for export due to the conditions caused by the war. Good prices prevailed through the year.

The vessels engaged in the Bank fishery brought home good catches. The Cape North fleet although bothered some at first by ice in obtaining bait returned with good trips. The fleet made good catches of fish on the fishing grounds in the Gulf of St. Lawrence off Perce, Quebec, where codfish were abundant.

The first fare of trawl Bank codfish arrived at Gloucester, June 15, schr. Athelete, having 280,000 lbs., and sold at $3.50 per cwt. for large and $3.25 for small.

Schooner Athelete, Capt. Thos. Benham, is also high line of the codfish fleet, having stocked $19,500.

The catch of the leading countries of the world, compared with 1914, has been as follows:

	1915		1914	
New England	370,235	qtls.	354,526	qtls.
Pacific Coast	124,000	"	105,530	"
Nova Scotia, Lunenberg	227,243	"	154,065	"
Newf'd and Labrador	1,282,088	"	1,149,168	"
France	242,103	"	241,714	"
Norway	2,385,714	"	2,910,714	"
Total	4,631,383		4,915,717	

Hake, Haddock and Pollock:—Hake have been in light supply, and sold during the year from \$3.1/8 to \$3.75 per qtl., from first hands. Hake, haddock and pollock have been in good demand for export. Haddock have sold from \$3,50 to \$3.75 per qtl. Large Cusk from \$4.25 to \$5.25, medium from \$3.25 to \$4.00. Pollock from \$2.75 to \$3.50.

Herring:—Pickled herring, owing to the light importations as a result of the war, have been in light supply, and receipts have sold at unprecedented high prices. Canadian and Newfoundland packers have put up herring in the Scotch style that have been in good demand.

The imports of herring into the United States for the ten months ending October were 51,404,992 lbs., valued at \$2,017,686, compared with 65,343,563 lbs. valued at \$2,141,884 for the same period in 1914.

Salmon:—Pickled salmon have been in light supply and sold at good prices as the amount cured on the Pacific coast was only one-third as much in the previous year.

Alewives:—Although the catch of alewives was good the amount cured was light and the end of the year finds these fish in short supply. Five hundred fish were taken at Edgartown on Feb. 25, the first catch at that place during the season, and was earlier than usual.

SMOKED FISH.

Box Herring:—These have been in good supply during the year and prices have ruled low. The supply that comes to this market is small in comparison with past years.

Bloaters:—Smoked bloaters have been in good supply as the Newfoundland fishery that supplies the fish for this article was quite successful. The receipts from the fleet the winter of 1914-15 amounted to 47 cargoes, 41,619

bbls. salt bulk, 4,489 bbls. pickled herring. The previous season there were 36 arrivals with 26,011 bbls. salt bulk, and 7,597 bbls. pickled.

The season of the winter of 1915-16 promises to be a successful one, and most of the cargoes were obtained at Bonne Bay.

The herring sold ex vessel at $5.25 per bbl. for salt bulk and $5.75 to $6.00 for barrelled herring, probably the highest prices ever paid.

Salmon:—The supply of these has been light, and they sold during the year at good prices.

Halibut:—The fleet engaged in supplying these fish only comprised two vessels. The schooner Maxine Elliot arrived Sept. 14, having 75,000 lbs., and reported fish scarce and weather conditions unfavorable.

Finnan Haddies:—The output of finnan haddies has been light as during the smoking season fish were in light supply and sold at high prices. The receipts from Nova Scotia have increased.

CANNED FISH.

Sardines:—These have been in good supply and sold at low prices. A large quantity went into consumption. The pack, which is estimated at 1,800,000 cases, has been largely distributed.

The pack in 1914 amounted to 1,600,000 cases. The end of the season of 1915 the pack was light, and prices advanced, and the new season will open with light stocks on hand.

Lobsters:—Owing to the light demand for export, the total pack in Newfoundland has been light. The total pack amounted to 5,579 cases, compared with 11,000 cases the previous year.

The total pack in Canada for the nine months ending December 31, 1915, amounted to 157,416 cases, compared with 145,200 the previous period.

Salmon:—The pack of salmon on the Pacific coast has been 7,998,601 cases, against 6,781,282 cases the previous year.

Clams:—Canned clams have been in fair supply, and the pack was an average one. Prices obtained for them was about the same as in the previous season.

THE WORK OF THE PENNSYLVANIA FISH COMMISSION

By N. R. Buller, *Commissioner.*

The Department of Fisheries of the State of Pennsylvania was organized under the provisions of the Act of April 2, 1903. The act authorized the appointment of a Commissioner of Fisheries and four other citizens of the Commonwealth, who together should constitute the Fisheries Commission. It also authorized the appointment of a clerk and stenographer and the Department was empowered to take charge of all hatching and fish cultural stations in this Commonwealth.

The duties of the Department of Fisheries are to provide for the protection and propagation of fish and to promote and encourage the development of the fishery interests; to obtain and publish information respecting the extent and conditions of the fisheries of the Commonwealth; and to make rules and regulations for the enforcement of all laws designed for the protection, extension and propagation of fish.

The Commissioner of Fisheries is the president and executive officer of the Fisheries Commission, and is also chief superintendent of all hatching stations and fish cultural establishments now existing or which may hereafter be established. He has full control, direction and management of all fish wardens, or water bailiffs, and of the work of the enforcement of the laws relating to the protection, propagation and distribution of fish. All fish wardens, constables, police, sheriffs and guardians of the peace, are required to make prompt report to him of all cases of violation of the laws relating to fish.

The Department has under its control six hatcheries which are devoted to the hatching and propagation of fish. These establishments are located in Erie, Centre,

Note—A portion of an address delivered before the Third Pennsylvania Welfare, Efficiency and Engineering Conference held at Harrisburg, November, 1915.

Wayne and Philadelphia counties and are each in charge of a superintendent, said superintendent being responsible for the operation of the hatchery to the Commissioner of Fisheries.

Experience has shown that economy in any business is only attained by the use of the latest and most improved methods, and the Department, since my incumbency, has devoted much time and labor to the rehabilitation of the hatcheries, to bring them up to the highest point of efficiency, so that they will be entirely up to date in every way for the propagation of fish, and when they are completed will be a credit to the Commonwealth. The old wooden structures are being replaced by substantial buildings of concrete, brick and steel.

The next factor is efficiency, because without efficient workmen, the best implements are no better than poor ones. It is here that the Department finds itself badly handicapped, on account of all the hatcheries being undermanned.

The work of the fish culturist is hard and the hours long, and it is only after years of training that a man attains that efficiency which is so essential in the propagation of fish. The men are now not only overworked, but are unable from the smallness of their number to get all out of the hatcheries that these would do if properly manned. Lack of appropriations accounts for this condition. Too much water running in a trough or battery would mean destruction to millions of eggs or fish, and the same would result from the stoppage of the water. Hence, the troughs and batteries must be under the constant and trained eye of some one all the time. The attendant must be always on the alert to detect the first symptom of trouble among his charges, and be ready at an instant to meet the trouble. Contagion spreads like wild fire and may undo the work of months. In shipping fish the messenger must be one who understands the habits of his charges, and see to it that the water is kept aerated and at the proper temperature, for without this only dead fish will reach the recipient. The

messenger, it might be well to state, accompanies the fish from the time they are placed on the train in shipping cans at the hatchery, until the last can of fish is delivered to the applicant, oftentimes making it necessary for him to be on duty all night and part of the next day without any sleep. Each applicant is requested to report to the Department the condition of the fish when they are received. In this way the Department is in possession of much valuable information which assists it in its work.

It has been difficult to keep men in the employ of the Department owing to the inadequate salaries that the Department is able to pay under the appropriations made by the Legislature. As the men are trained by the Department and become efficient they are sought for and bought up by offers of a much higher salary than the Department is able to pay. The result is that the Department makes the man and some one else gets the benefit of the training.

What is true of the hatcheries is true of the *field work.* Field work is really as important as the work at the hatcheries. It means the gathering of the spawn from the fish in the natural waters that would otherwise be lost. The millions of eggs gathered at Erie would be entirely wasted were it not for the efforts of the Pennsylvania Department of Fisheries in collecting them, hatching them and planting the young fish in the lake. This is shown by the fact that the supply of fish is kept up and that the port of Erie, today, is the largest fresh water fish market *in the world,* yet Pennsylvania has only forty miles of shore line on the lake. The people of Pennsylvania should be proud of this distinction as it means much to the Commonwealth in the commercial and business world. The amount of nets set every day runs into hundreds of miles and the production of fish last year was 9.205,767 pounds, valued at wholesale at $393,700.48, or about 4½ cents per pound. These figures convey forcibly the value of the fish business in Lake Erie, where the city of Erie is only one of a number of fishing ports. The value of the boats and tackle used

in taking the fish and the warehouses where they are handled runs into millions of dollars and gives employment to hundreds of men.

The most remarkable thing, however, in this matter and one in which the Pennsylvania Department of Fisheries takes pride is the fact that all this immense business is due to the artificial propagation of fish by this Department, by the United States Bureau of Fisheries and other State Commissions, and the whole restocking is done by saving the eggs which would be a waste product if it were not for the work of the hatchery men. There is not the slightest question in the mind of any fisherman as to the value of the work done by the Pennsylvania Department of Fisheries in this matter, because it was not many years ago, before the artificial propagation was taken up, that the catch of fish had so fallen off that the pursuit of fishing was no longer profitable.

The figures given above do not convey entirely the immensity of the business because they show the wholesale prices and the persons who use this large supply pay from 50 to 100 per cent. advance on these figures on account of freight and handling by the fish dealers. Taken altogether the fish industry at Erie is a most valuable object lesson as to the value of artificial propagation of fish in furnishing a very important food supply to the people. If Lake Erie, with the tremendous drain made upon it by the fishermen, can be kept stocked with fish, it shows that the other lakes and streams in Pennsylvania can also be restocked to their former productiveness if the hatcheries are worked to their full capacity and the fishermen observe the laws against wasteful and destructive methods of fishing.

Another duty which devolves upon the Department is the enforcement of the laws governing the protection of fish in our streams. The enforcement of the law comes under the small force of wardens which the Department is able to employ. The law allows the appointment of 30 citizens to act as fish wardens but unfortunately the Legislature appropriated only sufficient money to employ reg-

ularly ten men. This small force is expected to cover this great Commonwealth of ours with its numberless miles of streams and every warden is obliged to hold himself in readiness to go to any part of the Commonwealth on a moment's notice. This very largely increases the traveling expenses pro rata, because the men have to travel such long distances. It is hoped that the importance of this branch of the work of the Department will be realized and enough money appropriated to allow the employment of the 30 men. The wardens also have to look after the pollution of the streams and are now giving this their serious and careful attention. Under the provisions of the Act of May 1, 1909, the Department is given the authority to keep the streams clear of pollution, and this is the most serious and stupendous question which the Department is called upon to face.

Much time and thought has been devoted by the Legislature in the past half century of this Commonwealth and other states in making laws which would restore the streams to their original purity, prevent the wasteful and destructive devices from being used, and at the same time establish plants where fish can be raised artificially and used to restock the depleted streams. Yet the man who is fishing has found himself face to face with the fact that the laws do not enforce themselves, but can only be enforced by the consent and help of every citizen who believes that these laws are justified.

The common law which is the basis of our laws is merely crystalized common sense, evolved from the necessity and demands of the people for protection in property and personal rights. Around this there have grown up statutory laws which are enactments of the representatives of the people called for by the force of circumstances and by new conditions that constantly spring up. In most cases their proper enforcement demands that the public be taught their reason why and the benefit to be derived from their enforcement. This is largely true in the case of the laws governing the fishing which involve the protection of the fish and the clarification

of the streams and the restocking of the same by artificial methods. As the population grew and the number of fishermen increased it became necessary that the rights of the people in the fish should be guarded by law in the same manner as the rights of the people in property are guarded. It is a self evident proposition to people who look into the matter that fish should not be taken during the spawning season, and while on the nest, or else there will be no supply of young fish to grow up and take the place of the larger ones which furnish the sport and food.

No sane person would take the setting hen from her nest to furnish a meal for the suddenly arriving guest, and the same should be true in regard to taking a fish which is guarding its nest, and at which time it is as easily caught as the hen on her eggs. The farmer who kills all his chickens before they reach the egg-laying period will in a short time have no eggs, and the same is true of the persons who take the small fish before they reach the size and age when they can reproduce themselves.

It is to prevent such wasteful destruction that the laws were formulated and if the people can be educated to understand the reasons for these laws, as set forth above, there will be as common an assent to their enforcement as there is to the laws protecting people in their rights of property.

The fish of the State are the property of the Commonwealth and are for the use and benefit of the whole people, not only as a very important food supply, but as a means of sport and recreation. The importance of laws protecting fish from wasteful methods of fishing are not new, as we find them to have been enacted in England as far back as the twelfth century. Having taught the people the importance of the laws protecting the fish so that they will propagate and multiply, it will be an easy matter to create an aroused sentiment of the absolute importance of keeping the waters of the Commonwealth pure and undefiled so that the fish may live and thrive therein. In fact public sentiment is aroused to such an extent at

this present time that the Department is receiving complaints daily with reference to the pollution of some streams.

I have given this question of pollution of the streams much thought and the Department now has a plan of filtering refuse from the various manufacturing establishments throughout the Commonwealth which it will recommend and which it knows from practical demonstrations will absolutely prevent refuse from getting into the streams and which can be installed at a very moderate cost to the manufacturer or mine owner. I have had this filter system patented, paying for same out of my own personal funds, and will turn the patent rights over to the Commonwealth of Pennsylvania insofar as the Commonwealth is concerned. This system of filtration is the fruit of much thought and time given to it by one of the wardens of the Department, Mr. Albert, and myself and we know that it will do the work. The Department will be pleased and intends to furnish blue prints of this system to every manufacturer in this State and will insist upon it being installed as it has so much confidence in its practicability that it does not hesitate to recommend its installation. This system of filtration will take care of and purify refuse from tanneries, dye works, chemical mills, oil refineries, mines, nitro glycerine works and creameries. The Department has on file in its office scores of letters from manufacturers in this State who are only waiting for the blue prints to go ahead and install this system. The Department has found that the manufacturers as a whole are willing to cooperate with the Department in its work, which is very gratifying and now since it has something which it can stand back of it expects to accomplish much along this line of work. It is the biggest and most serious question the Department of Fisheries of Pennsylvania has to contend with today and, with the hearty co-operation of all those who are interested in the preservation of fish life in our streams, the Department expects to restore the streams to their former pure state so that there will be good fishing for all.

The Department of Fisheries is very much in earnest in its efforts to bring about the clarification of the streams, because its success in restocking the streams and waters depends almost entirely upon the ability of those waters to sustain fish life, not destroy it.

In order to interest the growing generation in the protection and preservation of fish life the Department has had prepared a Bronze Cabinent, known as "Bulletin Number 9," in which it has placed a number of vials containing some phases of the growth of the fish from the time it is in the embryo in the egg until it has started in the race for life. The specimens are taken, in one case from the trout as the representative of the game fishes of the Commonwealth, and in the other instance from the white fish as the representative of the commercial fish.

There is nothing more important in the eye of the Department than the enlisting of the rising generation as the friends of the fish. If the boys and girls of the Commonwealth can be shown how the fish lives, its habits, its instincts, and all the various phases of its life, they will become interested and incited by the interest, will be impelled to follow the study as they grow older. The more thoroughly they acquire an interest in the mysteries of the lives of the dwellers in the water, the more they will become convinced that the requirements of the laws which have been enacted to safeguard the fish are necessary for its protection in these days of constant growth in population. Describing the cabinet, a bulletin has been issued which tells of the characteristics, of the fish, where they differ, and of the growth from the embryo to maturity.

To the person who knows nothing of its life and habits, the fish represents only so much of a portion of man's food. But to one who studies the life of the fish and its habits, there is opened a volume as interesting as any upon the book shelves of the library.

The Department has had prepared a bulletin which treats of the capabilities of an acre of water in raising

fish and is pleased to say that it is one of the most popular ones compiled by the Department. The co-operation of the farmers is needed by the Department, because if the farmers will take up the culture of fish they will be able to add largely to the food supply of the people, which in these days of high living is very essential. It has been said that it is not the "high cost of living," but the "cost of high living," which keeps the prices of commodities up, but I will leave that for you to decide.

NOTES ON ONEIDA LAKE FISH AND FISHERIES

By Chas. C. Adams and T. L. Hankinson.

"A systematic study of the water life of our State should be made without delay and with the utmost thoroughness in detail. * * * Information of this kind is greatly needed, and is received slowly because the number of observers in the field is very limited. New York has not done as much work in the study of the life histories of its fish as some other States, and yet the importance of its assets in this direction is out of all proportion to the outlay of effort and money devoted to biological surveys." Dr. T. H. Bean, Fourth Annual Report, New York State Conservation Commission for 1914, p. 333, 1915.

INTRODUCTION.

The New York State College of Forestry at Syracuse is located within less than an hour's trolley ride of Oneida Lake. This lake is the largest body of water wholly within the state. It has an area of about 80 square miles, of which about 13 are of shallow water, abounding in water plants, fish food, and suitable breeding places for a large number of species. From the standpoint of food and game fish this lake is one of great importance and there has been no comprehensive working plan for the lake toward which its management might be directed to produce the maximum amount of food and game fish. Thousands of people from Syracuse and the smaller neighboring towns fish there. This is a very important lake for eels and other food fish, and the frog industry is the most extensive in the state, and one of the most important in the United States. Clearly such a large lake should not be managed solely to the angling interests, but should produce an abundance of fresh food fish for this part of the state. There is as much reason for the *diversified use of the waters*, causing them to be used for recreation (picnics, boating, angling, etc.), for the production of food, as a part of the canal system (for transportation and for water storage) as there is for the diversified utilization of farm and forest lands (cf. Adams '16, Diversified Forestry, Jour. N. Y. State Forestry Associa., Vol. 3, pages 25-26). Econ-

omically, therefore, it is unwise to advocate the use of Oneida Lake primarily for angling as some enthusiasts are inclined to do. It should also produce much excellent food fish.

Considering the importance of this lake, it is strange indeed that so little accurate information is recorded about its fish, although a State Hatchery has been located upon its shores for several years. New York State has indeed been backward instead of leading in the study of its fresh water resources. This condition of affairs was soon realized, particularly with regard to Oneida Lake, when the college attempted to utilize it for field excursions and demonstrations in its courses devoted to training foresters in the elements of fish conservation, protection and breeding. It was early learned that the fish of the lake must be investigated carefully and in detail if a firm foundation is to be laid for sound instruction, and furthermore, if the best use is to be made of this resource at the door of the college. In addition to this educational problem, the college has other obligations which relate this lake study to its investigative work on the utilization of forest lands. Most forest lands contain, as in the Adirondacks and Catskills, a large number of lakes, streams and swamps which should be made to produce game and food fish. Thus on the investigative side this is the continuation of a policy initiated by Dean Hugh P. Baker when he published the paper by Professor W. M. Smallwood, entitled: "Preliminary Report on the Diseases of Fish in the Adirondacks," etc. (Technical Pub. No. 1, 1914, N. Y. State College of Forestry, Syracuse). As rapidly as possible the college will extend its investigations to other lakes and streams, and in this work it seeks the co-operation of local organizations wishing surveys made in their vicinity, as such assistance will hasten the progress of this kind of work.

In the study of Oneida Lake, naturally, the first step was to make a general inventory of its fish population and their associated animals and plants which directly or indirectly influence them. In August, 1915, work was

begun, under the supervision of the senior author, and with the co-operation of the junior author, and Mr. Frank C. Baker, Zoological Investigator of the College. Mr. Baker made a special investigation of the molluscan life of the lake, as related to the fish, and the results have been published (Baker '16) as a bulletin by the college, to which the reader is referred for a summary of the American work on the relation of molluscs to fish, particularly as fish food, and for the results of a detailed study of the stomach contents of many Oneida Lake fish. This is an important investigation and the first of the kind ever made on Oneida Lake.

Up to the present time the western fourth of the lake has been examined, and the present paper is intended to indicate only the general phases of the study. The detailed results will be published by the college as a Technical Bulletin. In addition to the general inventory, an effort has been made to increase our knowledge of the relative abundance of the species, their habitats, habits, feeding and breeding grounds, food, enemies, and associated vegetation. Upon the basis of such a survey it is hoped that more detailed studies will be made which will ultimately lead to the intelligent management of this important lake. During the summer of 1916 these investigations will be continued.

PHYSICAL AND VEGETATIONAL FEATURES OF THE LAKE.

The physical features of the lake have recently been well summarized by Baker ('16) from which the following items are taken: The lake is 21 miles long with a maximum width of 5.5 miles, a maximum depth of about 55 feet, and the shores are generally low and bordered, particularly at the western end, by very extensive shallow water areas and swamps. The shore line is about 65 miles long. The area of the lake is about 80 square miles of which 6.8 square miles are not over 6 feet in depth, and between the 6-foot and 12-foot countours there are 6.2 square miles; the total shallow water area is thus

13.03 square miles, or 16 per cent. of the total area of the lake. The lake is thus both large and shallow and in striking contrast with other New York lakes and the Great Lakes, which also have but little shallow water.

The shallow waters are usually bouldery, particularly the projecting points, and in the bays sandy, with organic muds in the most protected coves. The shallow waters abound in vegetation, except upon exposed points and shores where wave action is too strong. On moderately exposed places water willow (*Dianthera*) and bulrushes (*Scirpus*) thrive, while in the bays a great variety of water plants abound, including *Valisneria, Castalia, Decodon, Myriophyllum* and many others. This lake is particularly favorable for the study of the relation of water plants to fish.

ANGLING ON ONEIDA LAKE.

It is seldom that a large inland city is located so close to a large lake abounding in game fish. The exceptional opportunities about Syracuse for anglers are much appreciated, as is shown by the large number of persons who belong to angling organizations. The oldest and largest organization, the Anglers' Association of Onondaga, has over 600 active members. This association has not only planted millions of fish, received from the Federal and State authorities, but has recently, in co-operation with the college, established a fish nursery at the College Experiment Station at Syracuse for rearing young fish to a favorable planting age. These facts are indicative of the character and amount of interest shown in the game fish.

If one attempts to summarize approved methods of angling in Oneida Lake, much divergence of opinion is found. The number of "best methods" is amazing. It calls to mind the difficulties encountered in any effort to determine the "best" in politics, automobiles, etc., because of the diverse personal preferences. As representative opinion, the following has been prepared, on

request, by Mr. A. L. Bishop, President of the Anglers' Association of Onondaga, who states that: "The Oneida Lake game fish may be rated as follows in the order of their preference as game fish: Small-mouthed Black Bass, Pikeperch, Large-mouthed Black Bass, Yellow Perch, Pickerel and Bullheads. An approved method for angling for Pikeperch is to troll the bottom with a small spoon, attached by a copper wire leader 10-12 feet long; in June on stony bottom of moderate depth, in July in deeper water. Bass to be taken by still fishing, with live bait (crawfish, locally known as 'crabs,' and minnows), or with wooden bait with casting rod. Perch are taken by still fishing, live bait (minnows, 'crabs,' or worms) fish eyes, or scarlet ventral fin of the perch. Pickerel are largely taken with a large trolling spoon (larger than for Pikeperch), to a much less degree by still fishing, with minnows. Bullheads are taken at night with worms."

Without a knowledge of Mr. Bishop's preceding section, Mr. W. H. Weston, Division Chief Game Protector of the State Conservation Commission, has prepared the following statement, using information from a number of his wardens:

APPROVED METHODS FOR ANGLING ON ONEIDA LAKE ARE.

1. Pikeperch. Trolling spoon; bait, minnows; still fishing in shallow bouldery bars early in the season, later, in July and August, in deep water, with worms.

2. Small-mouthed Black Bass. A fish of uncertain habits in taking bait; crawfish or "crabs," minnows, worms, grasshoppers, and crickets are recommended. A trolling spoon, hauled very rapidly over bars in shallow water without a sinker and with a cotton line gives good results. At times fly fishing is successful.

3. Pickerel. Trolling, bait casting, with frog, minnow or wooden bait, at the surface or below it, is approved.

4. Large-mouthed Black Bass. Same methods as for Pickerel.

5. Yellow Perch. Still fishing, with bait of worms, small minnows, pieces of perch with skin removed, perch eyes, reddish ventral fin of perch, and by fly fishing.

6. Pumpkinseed. Still fishing with worms, or fly fishing.

7. Rock Bass by trolling spoon, or line baited with small minnows or "crabs."

8. Bullheads. Line fishing with worms, crab "tails," minnows (dead or alive). June the best month for fishing."

THE FISHERIES OF ONEIDA LAKE.

The large amount of animal food produced by the lake and taken in that vicinity is a subject not generally appreciated even locally. The eels and frogs easily lead in importance. At our request the food fish of the lake has been rated by Mr. Hiram N. Coville, a fish dealer living at Brewerton, at the outlet of the lake:

1. Eels.
2. Pikeperch, Yellow Perch, Bullheads and Pickerel.
3. Pumpkinseed, Black and Red-fin Suckers.
4. Rock Bass.
5. Catfish (the kind with a forked tail).
6. Oneida Lake Whitefish or Tullibee.

The Tullibee or Oneida Lake Whitefish is sold fresh or salted. For salting they are opened along the back, salted to draw the blood, then packed in dry salt. In this manner 400 to 500 pounds are salted each year of the four to five tons of whitefish handled. Pikeperch and Yellow perch are taken by "tipups" through the ice. Small minnows are used for bait for Perch in this ice fishing.

At the State Hatchery at Constantia special attention is given to Pikeperch, Small-mouthed Black Bass, Yellow Perch and Oneida Lake Whitefish or Tullibee.

EEL INDUSTRY.

We are indebted to Mr. C. F. Davison and Mr. H. N. Coville for the following items concerning their fish business. Eels are taken in various parts of the lake, but the main catch is made at Caughdenhoy, four miles down the Oneida River, just below the large dam, which controls the level of Oneida Lake. Here there are two rows of weirs, each consisting of three traps or pots. The eels when mature descend the river to spawn in the sea and are trapped on this journey. The eels are taken from the traps and stored in cages until a sufficient number has been accumulated to sell. These are sold at Brewerton to Davison and Coville, who smoke and market

them. About 100 tons of eels are handled a year. Of these about three tons are smoked. About 300 pounds are smoked each week, from the middle of May to the middle to September, or in about 20 weeks. The eels are skinned, cleaned, split open, washed and salted, rinsed and hung up to drain for an hour or so in the smokehouse shanty. A wire screen is suspended below the eels to catch them in case any fall, as they are liable to do if cooked too rapidly, preliminary to smoking. A quick fire is started of corn cobs and sawdust to cook them and then the fire is converted into a slow smudge. By adding sulphur to the fire a rich brown color is given which greatly aids the sale. The time required for smoking varies greatly, from 4 to 15 hours. The causes for this great difference in time are not known. The smoked eels sell wholesale at 20 cents per pound, the undressed eels retail at 6.5 cents per pound, and the dressed unsmoked eels at 10 cents per pound.

The large catches of eels follow a strong east wind which, during July and August, blows toward the lake outlet. The average weight of individuals is about four pounds. Mr. Coville had one weighing 7¼ pounds, which was probably about 3½ feet long.

FROG INDUSTRY.

The frog industry about Oneida Lake is the most extensive in New York. It is conducted on a scale that is surprising to many persons, particularly to the people of Syracuse. The kinds of frogs concerned are almost exclusively Leopard Frogs (*Rana pipiens*, Shreber), Green Frogs, locally known as "Clinkers" or "Cow" Frogs (*Rana clamitans*, Lat.), the Pickerel or Swamp Frog (*Rana plaustris*, Le Conte) and rarely examples of the Bull Frog (*Rana catesbiana*, Shaw).

There are two important methods used in catching frogs. In one case men and boys tramp the borders of the lake and swamps and the upland fields, singly or in small parties, carrying clubs about three feet long. The

frogs are flushed and as they alight a blow is struck with the club, killing them. In this manner from 600 to 800 frogs may be caught in a day, from July until the winter season sets in. Mr. H. N. Coville has taken early in August 1,276 frogs between 9 A. M. and 2:30 P. M. or 5½ hours of work. This is an exceptional record. It was during a drouth when the frogs had congregated in short grass, grass as short as in a closely cropped pasture. When the haying of timothy and clover begins early in July, the frogs leave the fields and go to the short pastures, just as during a drouth.

The second method of capture is by the use of screens. This is used in the fall when the frogs migrate from the fields and swamps toward the lake for hibernation. This migration is not regular, it takes place mostly at night, particularly during warm rains, after a light frost. Taking advantage of this migrating behavior, cheese cloth screens, about 18 inches high, supported by sticks, are placed along the shore to intercept the migrating frogs. At intervals of two or three rods, nail kegs, carbide cans, or post-hole like excavations entrap the frogs which, failing to surmount the screen, wander along it, and fall in the traps. The frog catcher has only to collect the frogs from those traps. Late in the season one may find various sized frogs, mice and other small mammals drowned and frozen in these small wells.

The screens have to be placed far enough back from the lake shore to avoid water rising to near the surface and thus destroy the traps. On swampy ground the holes are similarly obliterated by the water. To overcome this difficulty, Mr. A. W. Thierre, of Lower South Bay, has devised a trap of woven wire screen; with a one-half inch mesh. If this trap was placed at an opening in the screen, which is not the case, it would allow the undersized frogs to escape and to reach the lake and find proper winter quarters, while the screens tend to destroy both the smaller kinds of frogs and immature individuals of the larger species. This wire trap has an inclined surface up which the frogs crawl, and from which they

fall into the trap cavity, and from which they seldom escape. Thierre also uses a large minnow box to store his frogs, until delivery to the dealers.

By means of the screens and traps a single night's catch may amount to about 500 pounds, from about a half mile of screen in a good locality. As much as $70.00 has been paid for a single catch.

Mr. Coville, who has had much experience in catching frogs, informs me that the frogs near the swamps are more abundant, but smaller than on the uplands. It takes from 40-50 swamp frogs to make a pound of frogs legs for market. Of the larger upland frogs it takes a smaller number, from 25-35, to make a pound of legs. The average for mixed lots, of swamp and upland frogs, range from 25-40 to make a pound of legs. Coville attributes the differences in the frogs of these two habitats to the more abundant food on the uplands, where there is more food and fewer frogs competing for it. Coville estimates that about 20,000 upland frogs, live weight, make a ton; about 30,000-40,000 of swamp frogs to the ton, and an average mixed lot will contain about 28,000 to 30,000 frogs. In the fall of 1915 Mr. Coville had on hand in his cages about five tons of frogs, or about 150,000 frogs.

These estimates of the relative differences between swamp and upland frogs are a rough measure of the degree of productiveness of the two kinds of land, and are probably surprising to most persons who naturally look to the swamp as the most favorable habitat for the frog. A valuable suggestion, bearing on frog breeding, is made by these facts. This is that a frog farm, if on swampy land, must provide for feeding the denser population or the frogs will be small, or it should provide for upland feeding grounds. Of course, part of the swamp frogs might be collected and taken to the uplands, after the Danish method of transplanting Plaice to better feeding grounds, and allowing them to grow, before marketing.

Davison and Coville conduct a gross business of about $15,000 per year in frogs alone. One customer bought between June 1, 1915, and March 1, 1916, $1,687.50 worth of frogs' legs. When sold per hundred, live weight, large and small, the price ranges from 30 cents to $1.50, or averages $1.05. The legs sell per pound, large and small, from 10 to 50 cents and average 35 cents per pound. An expert can dress between 15 and 16 hundred frogs per hour, but an average rate is about 1,000 per hour.

ANNOTATED LIST.

This list includes the species of fish, and the lamprey, known to occur in Oneida Lake. There are several collections which yet await critical examination, which will add several species to this list. Most of the data for this list is based on collections made by the authors during ten days of field work done between August 31, 1915, and September 10, 1915. To these have been added other records from collections made by the senior author before and since the joint collecting. A few published records have been used. The shallow water of the lake has been carefully examined from Constantia to Brewerton on the north shore, and from Brewerton to the mouth of Chittenango Creek on the south shore.

The brief annotations are necessarily general and the list simply shows our progress in finding the species present, but it will give a fair idea of the fish fauna of the lake, and some idea of its important fisheries.

Petromyzon marinus unicolor (De Kay), Lake Lamprey.

Evidently very abundant in the lake. They were frequently found on the under sides of our boats, to which they would attach themselves while the boat was in motion, and when the boat would stop they would release themselves. The many dead fish that we found in the lake frequently had lamprey marks upon them. Two cases were heard of lampreys attaching themselves to bathers, but the only harm done was the fright they

occasioned. The following kinds of fish were found dead with lamprey scars upon them: Dog Fish, Eel, Carp, Common Sucker, Chain Pickerel and Small-mouthed Black Bass.

Amiatus calvus (Linnaeus) Dog Fish.

A large dead one was found in the water at Walnut Point with a lamprey injury on it.

Salmo salar (Linn.), Atlantic Salmon.

Recorded on the authority of Sir John Richardson (1836), who in his Fauna Boreali-americana says that they enter Oneida Lake in May and remain until winter.

Leucichthys tullibee (Richardson), Tullibee.

A number of specimens were obtained from the market. The fishermen report the fish common in certain deep areas of the lake. Those seen by us were all of marketable size and in good condition. Fall specimens opened contained many well-developed ova. They spawn late in the fall. Locally known as Oneida Lake Whitefish.

Anguilla rostrata (DeKay), Eel.

A large dead one was found with a lamprey scar. The important eel fishery is at Coughdenhoy, four miles down Oneida River, the lake outlet.

Cyprinus carpio (Linn.), Carp.

A number found dead in the lake and several were secured from Coville, the fish dealer, at Brewerton. There is much local prejudice against this fish. Only scaled specimens have been secured by us.

Moxostoma aureolum (LeSueur), Red Horse.

None were collected by us, but the species is recorded from the lake by Jordan and Evermann 1896 and Bean 1903, but market specimens from Syracuse and Brewerton have been secured. It is locally known as "Red-fin Sucker."

Catostomus commersonii (Lacepede), Common Sucker.

Small examples frequently found on the shoals of the lake with other small fish. A large fish of this species found dead with lamprey scars, near the mouth of Scriba Creek, Constantia. Specimens secured from the market at Brewerton in May contained a large number of nearly ripe eggs. A variable irregular red line along the side is quite distinct in some specimens.

Catostomus nigricans (LeSueur), Hog Sucker.

One in the College of Forestry collection, that was caught near Constantia, and others were secured from Coville, fish dealer, at Brewerton.

Ameiurus natalis (LeSueur) Yellow Bullhead.

Ten examples were taken by us close to the mouths of shoals having muddy bottoms, and from sluggish streams entering Big Bay.

Ameiurus nebulosus (LeSueur), Common Bullhead.

Taken in places similar to those frequented by the yellow bullhead. With this last species it seems to associate, but it is apparently more common and more generally distributed, at least in shallow water, than the yellow bullhead. A few were found in the creeks at Constantia. Many very small ones, under two inches in length, were caught in Shaws Bay; and some similar ones were found in an isolated pool a few hundred feet inland from Johnsons Bay.

Esox reticulatus LeSueur, Chain Pickerel.

Common, but our collecting methods were not of a kind to get many of them in the lake. One taken in shallow water of Shaws Bay and one from Big Bay. Many were in a portion of Frederick Creek, where they were about the overhanging banks of a part of the stream in woods and where the water was quiet and its depth near a foot.

Lucius lucius (Linn.), Common Pike.

A market specimen from Oneida Lake was seen Nov. 30, 1915, which weighed 14 pounds and was 38 inches long. Locally this is known as the Spotted Pickerel or Pickerel.

Ambloplytes rupestris (Rafinesque), Rock Bass.

Apparently common in the lake. Small ones under two inches in length were frequently taken on the shoals and in creeks entering the lake. In deep water, twelve to eighteen feet deep near Grassy Island, a number of large ones were caught in the trap nets.

Pomoxis sparoides (Lacepede), Calico Bass.

A small specimen from Lower South Bay, and other specimens from the market at Brewerton. Locally known as Strawberry Bass.

Lepomis cyanellus (Rafinesque), Green Sunfish.

A small one taken in a minnow trap set in Big Bay Creek, near its mouth.

Eupomotis gibbosus (Linn.), Common Sunfish, Pumpkinseed.

Abundant in the lake. The only sunfish found in the lake by us that was abundant. Many small ones were taken in shallow water, but they were in greatest numbers on shoals with much plant life. Many large ones were in the trap nets that we saw raised from deep water near Grassy Island.

Micropterus dolomieu (Lacepede), Small-mouthed Black Bass.

Small ones were frequently found on shoals and in creeks. A number were in the trap nets raised near Grassy Island. The species is propagated at the State Fish Hatchery at Constantia.

Micropterus salmoides (Lacepede), Large-mouthed Black Bass.

A few small ones taken on a few shoals and in creeks entering the lake. Not as abundant in the lake as the Small-mouth.

Stizostedion vitreum (Mitchill), Wall-eyed Pike.

Abundant in deep water. A number caught in the trap nets set near Grassy Island. Many were seen that had been taken by fishermen from the lake. All were large; no small ones were seen by us and none was found on the shoals. Spawns in the spring in Chittenango Creek in large numbers. Locally called Pike or Pikeperch.

Perca flavescens (Mitchill), Common Perch.

Abundant and very generally distributed. Small ones in considerable numbers on most shoals that we visited. Large ones numerous in deep water. Fished for extensively through the ice.

Roccus chrysops (Rafinesque), Striped Bass.

A few large examples in the College of Forestry collection from Constantia. A single young specimen was taken (No. 314) in shallow water in October.

Lota maculosa (LeSueur), Burbot, Ling, Lawyer.

A few specimens have been secured, from the vicinity of Constantia, from Syracuse and Brewerton markets. It has been taken in trap nets in very large quantities.

The following species of little or no economic value, except as food for other fishes, also occur in Oneida Lake or its tributaries: *Hybognathus nuchalis* (Agassiz), Silvery Minnow; *Pimephales notatus* (Rafinesque), Blunt-nosed Minnow; *Abramis chrysoleucas* (Mitchill), Golden Shiner; *Notropis heterodon* (Cope), Black-chinned Minnow; *Notropis cayuga* (Meek), Cayuga Minnow; *Notropis hudsonius* (DeWitt Clinton), Spot-tailed Minnow;

Notropis whipplii (Girard), Silver-fin Minnow; *Notropis cornutus* (Mitchill), Common Shiner; *Notropis atherinoides* (Rafinesque), Shiner; *Notropis rubrifrons,* Rosy-faced Minnow; *Semotilus atromaculatus* (Mitchill), Horned Dace; *Semotilus bullaris* (Rafinesque), Fallfish; *Rhinichthys atronasus* (Mitchill), Black-nosed Dace; *Exoglossum maxillingua* (LeSueur), Cut-lip Minnow; *Erimyzon sucetta oblongus* (Mitchill), Chub Sucker; *Schilbeodes gyrinus* (Mitchill), Tadpole Cat; *Schilbeodes miurus* (Jordan), Brindled Stone Cat; *Umbra limi* (Kirtland), Mud Minnow; *Fundulus diaphanus* (LeSueur), Barred Killifish; *Percopsis guttatus* (Agassiz), Trout Perch; *Labidesthes sicculus* (Cope), Brook Silversides; *Percina caprodes zebra* (Agassiz), Manitou Darter; *Hadropterus aspro* (Cope and Jordan), Black-sided Darter; *Boleosoma nigrum olmstedi* (Storer), Tessellated Darter; *Etheostoma flabellare* (Rafinesque), Fantail Darter; *Etheostoma iowae* (Jordan and Meek); *Cottus ictalops* (Rafinesque), Miller's Thumb.

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SEWAGE DISPOSAL BY FISH CULTURE

By M. C. Marsh, *Gratwick Laboratory, Buffalo, N. Y.*

In "Les Miserables" Victor Hugo said that France was pouring into the Atlantic Ocean a half billion of francs every year. Bemoaning the waste of all the sewage of Paris, his imagination, delighting in paradox, burst into this glorification of the burden of the sewers:

"All this; a flowering field; it is green grass, it is mint and thyme and sage, it is game, it is cattle, it is the satisfied lowing of heavy kine at night, it is perfumed hay, it is gilded wheat, it is bread on your table, it is warm blood in your veins, it is health, it is joy, it is life."

It is surprising that it did not occur to the novelist in this flight of fancy that it is also the fishes swimming in the brook, for now reality has gone even further and made "it" the fish in the market and on the table. Fish culture has been linked with sewage disposal. Agriculture had already effected, in broad irrigation, a partial saving of the waste of the great potential values in sewage. Now comes fish culture with the hope of making the product pay all the costs of the transformation.

Sewage disposal, always one of the great current problems, has slowly progressed and various means have been more or less perfected for converting the offense and possible danger of city sewage into a harmless and unobjectionable effluent. Sewage irrigation projects, by which the sewage is poured over a large acreage which is then cropped, are comparatively rare and almost never pay the cost of operation. Sanitary conversion of sewage into something unobjectionable, but not valuable is successfully but not universally practiced and the processes are cumbersome and expensive. Even now most cities discharge their sewage unaltered into lakes, rivers or the sea and let it go at that.

The Germans, ever efficient in ways and means, have taken the next step. They have sought to change the

sewage into something valuable enough to pay the cost of the conversion, and on a small yet practical scale they seem to have succeeded. They invoke the aid of fish culture, use the sewage to rear young food fish to marketable size and persuade the market to buy them. This method has been developed by Dr. Bruno Hofer, the director of a government fisheries research station in Munich, Germany. Its practical use is best exemplified in Strassburg where a large pond system consumes a portion of the output of the city sewage in growing the German carp and other staple food fishes. Here the writer had the good fortune in May, 1914, to see this combined fish cultural and sewage disposal plant in operation.

As is well known, streams purify themselves finally of the sewage poured into them. The process is complicated and not thoroughly understood, but is known to depend upon a variety of conditions, such as temperature, rate of flow, oxygenation of the water, and to involve complicated chemical changes among which oxidations are of prime importance. Water bacteria in great numbers are necessary to the process and many higher forms of both animal and vegetable life play an essential part. A rather slow current is favorable to the abundance of these organisms and affords the necessary time for their action upon the sewage. In general then the slower the stream, other conditions being equal, the more minute life it is apt to contain and therefore the greater its sewage digesting ability or power to purify itself. Slow streams, however, have little comminuting effect on the gross particles of sewage, which requires therefore to be mechanically screened of the larger bodies in suspension in order that purification may proceed rapidly. If such sewage is evenly distributed throughout a slowly flowing stream containing a suitable fauna and flora, these latter digest and incorporate the sewage and increase thereby. If the stream is made a fish pond with a very slow current and conditions are under control and nicely adjusted, a profitable cycle may be established, consuming sewage on the one hand and produc-

ing fish on the other. In brief, Dr. Hofer's method aims at the transformation of the organic but lifeless substances held in sewage into living organisms, the sewage being thus used up in the process. Of the living product the larger eats the smaller through a series of forms ending in marketable food fishes.

A brief description of the Strassburg sewage-fish cultural station should begin with emphasis on its location and the nature of the land put at its disposal. This is of fundamental importance for the economy of the experiment, which requires that such land shall be of little value for other purposes, otherwise overhead charges will make the business show a loss. When a level tract of suitable size and small value located below the sewerage system and yet high enough to turn its effluent conveniently into the drainage of the region, is available, the first essential is complied with.

The Strassburg plant takes a sewerage composed of all the wastes of the city, domestic and industrial, besides the street washings. A small portion of the total sewage is diverted from the sewerage system. It is first subjected to coarse filtration or screening, which frees the sewage of the larger bodies floating or in suspension. This process yields daily about five cubic yards of an almost worthless residue. A part of the remaining sewage is pumped to sedimenting tanks where it is cleared of a large portion of the remaining suspended matter. The sedimented matter is periodically drawn off from the bottoms of these tanks to drying beds and yields a fertilizer of some commercial value. The now partially clarified sewage is ready for the fish ponds. It is, of course, nearly all water—more than 99.9% of it. It still contains by far the greater part of foreign matter which characterized the original sewage; for two-thirds or more of the solid matter in sewage is in solution. In this country ordinary town sewage has at most one-tenth of one per cent. of solid matter, and usually much less. About half of this is inoffensive inorganic matter, of which about three-quarters is dissolved. The other half is vegetable and animal matter and over half of this por-

tion is likewise in solution. It is this organic portion, whether suspended or dissolved, which makes sewage a hygienic or aesthetic offense, or both, as the case may be.

The sewage is now diluted with a considerable volume of clean water and distributed to shallow ponds of one or two acres in size, of which the best shape is somewhat rectangular and about twice as long as wide. The ponds convert a proportion of sewage representing about 6,000 of population, or that of about 800 persons per acre of pond area, which therefore covers between seven and eight acres. The sewage is let into the ponds at many separate places arond one end, a thorough distribution being of the first importance. The depth varies from twelve inches at the edges to twenty inches in the middle and three feet or more at the outlet. A slow current sets lengthwise of the pond and practically complete purification must be obtained before the outlet is reached. The borders of the ponds must be clear of trees or bushes hindering the free access of sunlight. In the ponds themselves certain water plants are provided—sweet-flag and manna-grass (Glyceria) near the inflow; Glyceria, Ceratophyllum and Myriophyllum in deeper parts, while undesirable plants are removed. The duckweed (Lemna) for instance led to such interference with the growth of algae and consequent oxygenation by blanketing the surface that young ducks were introduced to feed upon the Lemna. They were thus reared upon the products of the ponds and when fattened just before marketing contributed appreciably to the profits of operation. They were moreover of some use in aerating the water.

The ponds are first prepared by supplying them from other waters with large quantities of crustacea, insect larvae (Chironomus abundant), mussels and snails. Cyclops and Daphnia and related groups are very abundant and important in this stock of minute life; in fact pits are used for breeding these small forms. The young fishes which it is intended to rear are introduced in such numbers as appear suited to the fish cultural capacity of the ponds. These are then maintained for two or

three weeks by a flow of clean water and without sewage. After this preliminary period, the sewage is admitted to the ponds and its purification begins. The crustacea and other plankton multiply tremendously on this continuous influx of sewage which avails them as an unlimited food supply. In turn the young fishes find this minute life an abundant food suitable for their own rapid growth. The many forms of both animal and vegetable life which attain greater size are eaten by the older fishes. The species most commonly utilized have been the carp, tench and pike (Esox), but cat-fish, black bass, a flat fish and even the rainbow trout were contemplated as desirable food fishes which further experiment might show to be susceptible to this new method of fish culture.

The effect of the purification process can be seen very soon after the entry of the sewage. An appreciable cloudiness is caused in the water about the inflow end of the pond, due to the turbid sewage. This affects only a small portion of the pond, the turbidity soon disappears and the contents of the rest of the pond are clear enough to show plainly the vegetation and other organisms on the bottom. Progressively toward the outlet the water is more and more relieved of its sewage character until the effluent is said to be potable. The series of ponds and the disposal plant as a whole present a sightly appearance and resemble any well conducted fish cultural station. The process can not be said to involve a nuisance.

The purification process is rather delicately balanced and its successful and continuous operation depends on foresight and constant care. The various reactions are interdependent and must proceed with reasonable quantitative adjustment to each other, without which a preponderance of any one is able to disturb the co-operation of all. The most important index is the dissolved oxygen in the pond water, and daily estimations by color tests are made. Additional control is obtained by other chemical and bacteriological tests carried out every two weeks. The absolute and relative quantities of sewage

and clean water admitted to the ponds, the quantity and distribution of the higher plants, which afford protection and attachment for many animals, and lurking places for yong fishes, the adaptation of the stock of fishes to the capacity of the pond, these are prime elements in the even driving of the process. They require constant supervision and regulation. Moreover the method as a whole, while it has been made workable by repeated modification through a long series of experiments, will be further perfected by the experience gained from continued use.

As is not difficult to infer, the introduction of fish from the sewage ponds to the market as table fish did not fail to encounter the opposition of natural prejudice, even in Germany where the carp, the principal species produced by this method, is in high favor and where the public is highly amenable to reason. It required an organized campaign of education by means of lectures and various authoritative propaganda. It was explained that the carp in its natural habitat sought the vicinity of whatever sewers were available, finding there its food most abundant; that the public had long been eating carp bred under similar and less well controlled conditions; that there was no offense in or about the sewage fish ponds, as anyone might see by inspecting them; that there was no logical or hygienic objection to the use as food of fish grown in them; and finally by serving them to a representative public, directly from the ponds, these fish were shown to compete in attractiveness with any other. The whole product of the ponds is disposed of without difficulty in Strassburg. The fish are taken alive in tanks of water to the city and the consumer may make his choice of an obviously fresh specimen, a fact which no doubt facilitates the sale. The income from the sale of the total products of the disposal plant suffice, according to the management, to pay all the expenses of the process and leave a small margin of profit. Exact figures are not available, but the attainment of an even break between profit and loss has doubtless been the goal sought and one hitherto entirely beyond reach.

It is unlikely that more than a nominal excess of revenue over all the costs of operation is to be expected.

Two years ago this method of making sewage disposal economic by the aid of fish culture evidently had been stamped with the seal of official approval in Germany. A Hamburg commission had examined and reported favorably on the Strassburg installation, and had recommended tentative establishments in suburban sections in the region about Hamburg. In Strassburg itself it was learned that the plans and specifications for enlarging the system to the demands of the whole body of Strassburg sewage had been for some time completed, and had official approval, but the necessary appropriation of funds had not been made. It appeared that military influences alone had intervened to prevent this not inconsiderable public expenditure. In May, 1914, this seemed puzzling. Within less than three months war had broken out, and it may be inferred the Strassburg project is at least no further advanced.

The question arises how far these methods of sewage disposal are applicable in the United States. In some respects it is likely that greater difficulties will be encountered than in Germany. The public will regard fish raised from sewage with more suspicion than the Germans displayed toward them, and it will be less susceptible than the German public to efforts to counteract its prejudices in this respect. Yet conditions suitable for producing fish from sewage can undoubtedly be found at many places here. In localities with a severe winter climate there has been little or no experience with the method, and low winter temperature must reduce, modify or put an end to its efficiency. The Strassburg ponds are operated in a climate considerably milder than that of our northern cities.

THE ULTIMATE SOURCES OF MARINE FOOD

By Prof. Irving A. Field,
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The ocean as a source of food for human consumption always has been a subject of interest, but the attention given to developing the food resources of the sea has been almost nothing compared to that devoted to agriculture. Without exercising any intelligent control in the cultivation of marine food products we are now appropriating for use such food materials as happen to be produced within our reach just as primitive man in ages past depended on land plants and animals in an uncultivated and undomesticated state. At the present time we see the science of agriculture reaching a high stage of development. Most of our nation's land fit for growing crops has been appropriated for cultivation, scientific methods for increasing the yield have been developed, labor saving devices for reaping have been perfected and yet with it all our rate of food consumption is increasing more rapidly than the rate of production. The capacity of the soil to produce enough food for our rapidly increasing population is fast approaching its limit. Unless the chemists come to the rescue with inexpensive methods for rapidly combining the necessary chemical elements into palatable, digestible and nutritious compounds we shall have to devote our energies to the development of the natural food resources which lie in the waters covering nearly three-fourths of the earth's surface. A prominent authority once stated that four square feet of ocean was capable of supporting a human life. At first thought such a thing seems impossible, but a better understanding of the sea will show that his statement is not far from the truth. It is the purpose of this paper to point out the ultimate sources of marine food and the almost unlimited resources they provide for the production of human food.

A brief comparison of the conditions of life found on the land and in the ocean will help one to understand the wonderful opportunities which are offered for deriving food from the sea.

On the land there is one vast expanse of verdure. Plants of all sizes from the minute algae to the giant trees are abundant everywhere and they form the ultimate food basis for animal life. The animals for the most part are herbivorous. The Carnivora are comparatively few in number, which is a very important condition for if they should exceed the vegetable feeders in abundance it would soon mean extinction for both races.

In the sea, life conditions are very different. Vegetable life is as inconspicuous in the sea as it is conspicuous on the land. To be sure along the coast there is a fringe of sea weeds and floating in the middle of the ocean are great masses of algae such as the Sargasso sea; but taken as a whole the ocean is barren of visible vegetation. Under these conditions we find practically no animals that correspond to the terrestrial Herbivora. Most of the animals are carnivorous. A few fishes may browse on the sea weeds which fringe the shore or float in the water, but, on the whole, most marine animals are voracious beasts of prey. The larger species devour the smaller ones and these in turn feed upon those smaller than themselves. Furthermore animal life swarms in the sea in incredible multitudes. The naturalists of the Challenger expedition reported that the waters of the equatorial Pacific contained great banks of pelagic animals through which the vessel sailed. Chiercha wrote that the equatorial calms of the Atlantic are rich beyond all measure in animal life and that the water often looks and feels like coagulated jelly. The Challenger expedition reported having encountered banks of copepods a mile thick and on one occasion to have steamed for two days through a dense cloud formed of a single species, one found distributed from the Arctic regions to the equator. Of the fishes Professor Brooks says, "Herring

swarm like locusts and a herring bank is almost a solid wall." Goode tells of a school of mackerel which was estimated to contain a million barrels and of another which was a windrow of fish half a mile wide and at least twenty miles long. In the bays and estuaries beds of sea mussels are found containing 6,000 to 8,000 bushels to the acre.

How this vast multitude of animals can be supported in a region apparently destitute of vegetation has been a problem of investigation since the microscope came into use and it is interesting to note that the first serious contribution on the subject was written Oct. 16, 1699, by the old pioneer, Anton van Leeuwenhoek, who ground lenses and made his own microscopes. After observing the minute organisms which he discovered in fresh water by means of his microscope he came to the following conclusion: "If it be then asked, to what end such exceedingly minute animalcules were created, no answer can readily be given which seems more agreeable to the truth than that, in like manner as we see constantly, that the bigger kinds of fish feed on the smaller; as, for example, that the cod fish preys on the haddock and other smaller kinds of fish; the haddock again on the whiting; these on still smaller fishes, and among the rest on shrimps; and shrimps on still more minute fishes; and that this gradually prevails among all the kinds of fish; so that, in a word, the smaller are created to be food for the larger. Again, if we consider the nature of our sea, abounding with fish, yet having nothing at the bottom of it save barren sand: stored with various shellfish, yet destitute of every green herb; and if we, moreover, lay it down for a truth, that no fish can be supported on water alone, there will not remain a doubt, that the smaller fishes are destined, by nature, to be the subsistence of the larger." It is evident from Leeuwenhoek's illustrations that his use of the expression "smaller fishes" refers to what we now recognize in general as plankton, which includes both animal and vegetable organisms.

Peck, in his splendid paper on The Sources of Marine Food, gives us an excellent example of the food relations described by Leeuwenhoek. Reporting on the stomach contents of the squeteague he says, "On the morning of July 23 there was taken a large specimen whose stomach contained an adult herring. In the stomach of the herring were found two young scup (besides many small crustacea), and in the stomach of one of these scup were found copepods, while in the alimentary tract of these last one could identify one or two of the diatoms and an infusorian test among the mass of triturated material which formed its food. This is an instance of the universal rule of this kind of food: The squeteague captures the butterfish or squid, which in turn have fed on young fish, which in their turn have fed upon the more minute crustacea, which finally utilize a microscopic food supply." These microscopic organisms constitute an unfailing, ultimate food supply and without it the larger animals of the ocean whose chief business is to devour each other, would soon exterminate themselves. It consists of single-celled plants and animals, chief among which are the diatoms and radiolarians. According to Peck these two groups alone may be regarded as the great primary food supply for the larger marine animals. The diatoms in particular may be said to constitute the pastures of the sea.

How these minute creatures can support such a large and extensive fauna may be readily understood when their habits are known. They grow under far more advantageous conditions than our land plants and consequently grow faster, almost infinitely faster. Land plants have a portion only of their bodies in the ground and can absorb the mineral elements necessary for their growth only as the rains dissolve them. Being crowded into limited space and subject to seasons of drought and cold their growth is constantly arrested.

On the other hand the microscopic marine plants are bathed in a uniform solution of mineral food, they have the full benefit of the sunlight and the temperature of

the water is not subject to extreme changes. Under such conditions growth is so rapid that it passes beyond our powers of conception. Microscopic examination of water taken from almost any part of the sea shows that in reality it is a living broth. To give us a clear picture of the wonderful productivity of these unicellular organisms it requires the expression of the late Professor Brooks who says, "Their vegetative power is wonderful past all expression. Among land plants, corn, which yields seed a hundredfold in a single season, is the emblem of fertility, but it can be shown that a single marine plant, very much smaller than a grain of mustard seed, would fill the whole ocean solid in less than a week if all its descendents were to live. This stupendous fact is almost incredible, but it is capable of rigorous demonstration and it must be clearly grasped before we can understand the life of the ocean."

Until recently students of marine biology have looked upon diatoms as constituting the ultimate food basis of marine animals. Practical oyster growers in order to find out the best localities in which to plant their oyster beds have tried to determine the food value of the surrounding waters in quantity of diatoms per volume of water. In general it has been found that oysters and mussels thrive best where diatoms are most abundant. On the other hand investigations, made by Dr. H. F. Moore of the U. S. Bureau of Fisheries and others, show that the amount of diatoms consumed by shellfish is not sufficient to account for their increase in growth. The question then arises what is the source of the additional nourishment that they obtain? Some investigators say it is from the soluble organic matter in sea water which is constantly absorbed through the body surface, while others attribute it to the suspended organic particles which are taken in with the diatoms. The truth probably lies in the latter assumption as is shown by several very important researches recently conducted at the Danish Marine Biological Station.

Petersen, 1890, was the first to express the idea that the abundance of fish on the Danish coasts was due

chiefly to Zostera which is better known to fishermen as "eel grass." Petersen and Jensen (1911) tried to show that, in all probability, the plants of the eel grass belt, and not the plankton organisms should be regarded as the main sources of the organic matter of the sea bottom in Danish waters. Their reasoning is based on the fact that the quantity of carbon in a series of bottom samples is directly proportional to the amount of Zostera vegetation and not to the quantity of plankton present.

This study was continued in greater detail and published by Jensen in 1914. He shows that the eel grass plays an important part in the production of organic matter in the sea. In all the Danish waters he found fragments of eel grass deposited in greater or less quantities, for the most part in very fine particles as detritus. In this detritus he found comparatively few diatom shells. Much of the detritus particles were too small to be identified by the microscope as of eel grass or plankton origin. By chemical means, however, Jensen was able to determine the source of the organic matter in the sea bottom. He found that the eel grass cells contain a considerable quantity of starch-like substances known to the chemists as pentosans, whereas those of diatoms are composed mainly of silica and those of Peridineans of fairly pure cellulose. By comparing analyses of various bottom samples of organic matter with those of eel grass and diatoms the following conclusions were reached: "(1) In the more sheltered waters the organic matter of the sea bottom is to a pre-eminent degree formed by eel grass. (2) In the more open waters, at least half of the organic matter is probably formed by eel grass. (3) In the deepest waters the organic matter is probably formed chiefly by the plankton organisms."

Calculations on the production of phytoplankton (minute floating plant life) and eel grass per square meter have been attempted, but what has been done so far approaches a mere approximation only. In regard to the phytoplankton, Hensen (1887) figured that one square meter of surface produces annually 15-18 grams

of dry organic matter exclusive of the phytoplankton consumed by the surface fauna. The total production of phytoplankton he estimated to be 150 grams per square meter annually. Jensen by very careful calculations estimates that in the Danish waters about 100 grams of organic dry matter per square meter is produced each year by the phytoplankton. For eel grass the percentage of dry organic matter produced annually per square meter he found to be 1,920, 1,120 and 344 grams in good, moderate, and bad localities respectively. Eel grass beds cover about one-seventh of the area studied (between the Skaw and the Baltic) which means that the annual production of eel grass per square meter of the water as a whole is 120 grams of organic matter. Comparing the production of eel grass and plankton on a basis of Jensen's calculations we see that eel grass produces 120 grams of organic matter per square meter while the plankton produces 100 grams.

Now the question arises, how much of the organic matter from each source is deposited on the sea bottom? Undoubtedly much of the matter of the plankton dissolves following the death of the organisms due to the action of baceria. Admitting that a portion of the eel grass material is similiarly lost it is evident that the plankton organisms with their relatively far greater surface are in a much higher degree liable to destruction than the eel grass. Furthermore a large part of the plankton is devoured by the plankton fauna which would lead one to believe that but a limited portion of plankton production is deposited on the sea bottom. These calculations are supported by the results of chemical analyses of the organic matter in the sea bottom. Jensen has done this and states his conclusions as follows: "In the more sheltered waters the organic matter of the sea bottom is derived almost exclusively from the Zostera (eel grass); in the more open waters, it is possible that the plankton organisms may play a not altogether unimportant part as a source of the organic matter of the bottom."

The transformation of nitrogen during the decomposition of eel grass and its relation to the nitrogen content of the organic matter in the sea bottom was also investigated by Jensen. He found that the green eel grass is as rich in nitrogen as peas or beans, which contain about 3%. As the eel grass decomposes the percentage of nitrogen decreases until it is as low as 0.88%, then as decomposition continues it rises again up to 1.39%. Analyses of the organic matter in the sea bottom indicate that the average amount of nitrogen present is 4%. Thus it is evident that the organic substances of the sea bottom contain a greater proportion of nitrogen than the eel grass.

Why the organic matter in the sea bottom is so much richer in nitrogen than the eel grass from which it is formed chiefly is readily explained by Jensen. As has been shown the amount of nitrogen in the green eel grass is greater than that in the early stages of decomposition. Later the amount of nitrogen increases becoming much greater than in the green eel grass. The diminution in nitrogen during the first stages may be due to the fact that a portion of the nitrogenous protoplasm is dissolved in the sea water as the cells die. The increase in proportion of nitrogen in the final stages of decomposition may be due to two causes. (1) Either by the destruction of non-nitrogenous substances in the sea bottom to a greater extent than is the case with the nitrogenous matter, or (2) by the fixation of inorganic or free nitrogen by bacteria.

It has been established beyond all doubt that non-nitrogenous substances of the sea floor are to a very considerable extent destroyed by bacteria, at least one step in the process being the fermentation of the pentoses. Another is the formation of methane from the fermentation of cellulose. On the other hand it is probable that the nitrogenous substances are acted upon to a lesser degree due to the fact that they are comparatively easily transformed into humic compounds, which are less easily destroyed.

It is also possible that the excremental action of the fauna contributes to render the bottom richer in nitrogen. The nitrogenous portion of the bottom is indigestible while the non-nitrogenous matter contains considerable quantities of digestible pentosans. Hence when fed upon in the form of detritus by such organisms as mussels and oysters the non-nitrogenous matter would be removed and the nitrogenous portion returned to the bottom. This was well illustrated by comparing the composition of oyster excrements which consisted of almost pure detritus, with bottom samples taken at the same place where the oysters were found. The nitrogen of the bottom samples amounted to .187% while that of the excrements was .71%.

That nitrogenous matter of the bottom can also be increased by the fixation of inorganic nitrogen through the action of bacteria is likewise probable. The nitrogen may be taken from the ammonia or nitrates dissolved in the water or from the free nitrogen which is also present in solution. Bacteria such as *Azotobacter* and *Clostridium,* which perform this function, are of common occurrence on the bottom and a considerable amount of nitrogen fixation has been shown to take place where the vegetation is abundant.

In addition to the above sources of nitrogen it should be mentioned that the fauna itself, by dying and forming detritus, also serves to increase the amount of nitrogen in the sea floor.

A determination of the total quantity of detritus and plankton in sea water was also attempted. Ten liter samples of sea water from various localities were carefully filtered and the total quantity of detritus and plankton measured. It was first weighed and dried at 100° C. and then weighed again. Samples were also subjected to microscopic examination to determine the amounts of detritus and plankton organisms present.

The results were that nearly all the samples showed a greater proportion of detritus than of plankton. The weight of the dry matter in the residue varied between

9.6 and 72.3 milligrams per 10 liters of sea water. No relation could be shown to exist between the weather conditions and amount of detritus in the water.

The conclusion to be drawn from these results is that sea water is rich in the quantity of detritus it contains.

The next question which arises is, what value does this organic matter of the sea bottom possess as a source of nourishment for the benthos or bottom fauna?

Assuming that the organic matter of the sea bottom forms a source of nourishment for the majority of the fauna living in and near the bottom Jensen considered it advisable to investigate the question as to how far suitable nourishment for such fauna can be shown to exist among the substances of which the sea floor is composed.

Since eel grass contributes most of the organic matter of the bottom it was natural to examine quite closely the chemical composition of this weed. It was found to compare favorably with the composition of the common fodder grasses. Protein was found present to the amount of 7.5% and pentosan 8-9%. No fat determination was made.

When eel grass is treated with pancreatin from 23 to 26% of the nitrogen is digested. Since the eel grass contains 7.5% proteins, of which about ¼ is digestible by pancreatin the amount of digestible proteins contained may be put at 1.08%. Decomposed eel grass contains less nitrogen and is less digestible. For example black eel grass (dead) was found to contain 1.39% nitrogen of which but 6.6% was digestible. These figures should, however, in all probability mainly be taken as minimal.

Experiments on the digestible nitrogenous compounds in the sea bottom brought out the fact that there is only a very small amount of proteins in the bottom which are digestible with pancreatin. In fact the amount is so small as to be very nearly within the limits of possible error. The analyses for the top layer, however, give such positive results that it is justifiable to conclude that the upper-most layer of the bottom really

does contain a certain amount of proteins digestible by pancreatin. In the upper layer from 44 to 68 milligrams of digestible proteins per 100 square centimeters are found, which means that the amount of digestible proteins per square meter is approximately 5 grams.

On the other hand digestible non-nitrogenous compounds in the sea bottom consist of a fairly considerable amount of material in the form of pentosans amounting to from 0.3 to 1.0%. This is an important fact for there is reason to suppose that the bottom fauna is able to digest pentosan. It has been well established that herbivorous animals utilize pentosan as a food and Biederman and Moritz (1898) showed that Gastropods were able to digest pentosan. It is probable, therefore, that bivalves also can digest pentosan and that the considerable amount of pentosan present in the sea bottom besides other possible substances (hemicellulose generally) plays an important part as non-nitrogenous nourishment for a great portion of the bottom fauna.

In support of Jensen's observations Blevgad, 1914, has made an interesting study of the food of the commonest and most widely distributed bottom-inhabiting animals in the various communities of the Danish waters. His report is based on the analysis of stomach contents. Three main sources of nourishment for the bottom fauna of the sea were determined. (1) *Plants*—fresh growing plants of the benthos formation, chiefly eel grass which in the Danish waters produces about 8,232,000 kilograms annually. In course of time, this decays and falls to pieces forming (2) *detritus*. This includes dead or dying organisms or portions of them whether vegetable or animal in origin as are found in suspension (or solution in the sea water) or deposited on the bottom. Most of this detritus is of eel gras origin. (3) *Animal* or carneous food or the third source includes all living animals found in the sea, together with their carrion, save where these are to be reckoned as forming part of the detritus as just defined.

The plankton, heretofore considered as of greatest significance, he does not list as an important source of food. Whereas previous observers have emphasized the great importance of plankton, Blevgad emphasizes the importance of detritus. He furthermore questions Pütter's (1908) theory to the effect that the carbon compounds present in solution in the sea water are of very extensive importance as food for certain animals of the bottom fauna. At least it must for the present be regarded as unproved. It is possible, however, that some organisms may live on dissolved organic matter and so for the sake of convenience Blevgad classifies dissolved organic matter under detritus.

The commonest animal forms in Danish waters are classified into three groups according to their mode of feeding. (1) *Herbivores* which include certain Gastropods, two Echinoderms and some Crustacea. (2) *Pure detritus eaters* which comprise all the Lamellibranchs, Holothurians, Sipunculidae, Cumacea, Diptera larvae and Ascidiae, two Gastropods, Balanoglossus, Amphioxus, Ostracods, Bryozoa, Porifera and Foraminifera. The great mass of material in the alimentary tracts of these animals is detritus and when analyzed chemically it corresponds to that on the ocean floor. Plankton organisms are only incidentally present. These observations led Blevgad to make the extreme statement, "The living phytoplankton is thus of no importance at all as a food for the bottom fauna." (3) *Purely carnivorous animals* including a few Polychaeta, some Gastropods, some Crustacea, some Echinoderms, Coelenterates, Nemerteans, Planarians and Pantopods constitute the last group. Quite a large number of animals are both carnivores and detritus feeders.

The investigations tend to show the extreme importance of detritus as a food for the fauna on the sea bottom. To use Blevgad's words, "Detritus forms the principal food of nearly all the invertebrate animals of the sea bottom, next in order of importance being plant food from fresh benthos plants. The value of the live

phytoplankton in this connection is absolutely minimal, amounting in any case to nothing more than an indirect significance through the medium of the plankton copepods."

That detritus is formed so abundantly in the shallower waters of the ocean and constitutes such an important food supply for most of the bottom-inhabiting animals is of great significance in its bearing on the coming science of sea farming. If the investigators of the Danish Biological Station are right in their conclusions concerning the importance of detritus as a food for the benthos fauna then we shall have to revise our methods of determining the available oyster, mussel or clam food supply in the waters of a given locality. It also means that the available fields for the cultivation of oysters or other shellfish are far more fertile than we have ever dreamed in the past. The knowledge of the rôle played by detritus in its relation to the benthos fauna helps us to understand better the phenomenal growth which often takes place in many mollusks in the absence of an abundant supply of plankton. For example many mussel beds are known to yield on an average about 2,000 bushels annually and experiments have shown that one bushel of seed clams planted in a barren flat will yield ten bushels of marketable clams one year later. This serves to show what splendid opportunities for increased food production lie within our reach. Between the plankton organisms and detritus there is an inexhaustible ultimate food supply which can be quickly and readily converted into a form available for human consumption. A partial solution of the problem of the ever increasing high cost of living undoubtedly lies in appropriating this vast resource for greatly increasing our own food supply. Cultivating the ocean promises to yield the fisherman far greater returns, with less expense of time and energy, than the farmer is able to produce from the land. Each new discovery in marine biology is making it more clear that for the comfort and economy of the nation we ought to be doing more in the scientific development of our fisheries.

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PHYSIOLOGICAL CHARACTERS OF MARINE ANIMALS FROM DIFFERENT DEPTHS *

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I.—INTRODUCTION.

The sea is the largest single type of habitat and on account of its vastness we are accustomed to think of its life as comparatively uniform for slightly different depths, and of its conditions as essentially the same for closely connected parts and opposite sides of comparatively narrow channels. It was a matter of much surprise to the writer to find that marine fishes showed marked sensitiveness to slight differences in acidity and alkalinity, and that, as compared with the difference to which they respond, the differences in this respect between the two sides of the channel south of Brown's Island, Puget Sound (Friday Harbor, Wash.),† which is only about a fourth of a mile wide, are great. The water on the north side of the island is uniformly alkaline and suited to the development of the eggs of fishes and invertebrates which require an alkaline medium, while the water of the south side is acid much of the time and the eggs of various animals do not develop well. This difference is correlated with striking differences in vegetation and animal life which the casual observer would attribute to the difference in current and bottom, the south side being most strongly swept by the tide and rocky, while the north side is sandy and escapes the main force of the tide. In a paper by the writer and Mr. E. B. Powers, attention was called to the fact that slight contamination of the sea can have pronounced effects.

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* Contribution from the Puget Sound Marine Station.

† Biol. Bull. XXVIII: 315-334; also reprinted in *Fishing Gazette*, March and April, 1916.

The Baltic towns of the Hanseatic League were dependent in part upon the herring industry and after a century of great growth and prosperity fell into decline at the middle of the fourteenth century. Their prosperity was the accompaniment of the presence of great shoals of herring off the Island of Rügen in the Baltic. Their decline was caused in part by the failure of the herring industry and the supposed migration of the herring to the North Sea which has since been the centre of the industry. Schouwen (on the Netherland coast of the North Sea) appears to have been frequented by the herring shoals in preference to Rügen. The rapid growth of the Netherland cities, their supremacy and final separation from the Hanseatic League followed. A little later the herring again changed their haunts choosing the coast of Norway where both Norsemen and Netherlanders caught them. The Beukelszoon method of curing herring having come into use, nearness to home was no longer a necessity. The Norse fisheries flourished until 1587 when an "apparation of a gigantic herring frightened the shoals away." Thus it appears that the development of the herring industry in each locality led to the apparent desertion of the locality by the fish, though the migrations assumed by historians may be doubted. Was this due to the contamination of the sea by the cities, or merely to over catch? Whichever may have been the case it is certain that contamination will not invite runs of the herring. The common assumption that the sea is so large that pollution can not have a significant rôle is rendered entirely untenable by the greatly increased sensitiveness of the marine fishes as compared with the fresh water ones.

These unexpected differences in the character of the water near the surface and the sensitiveness of animals to it, are only excelled by the marked differences among animals of the same species from different depths.* Uniformity of physiological characters has been commonly assumed. It has been customary since the early writings

* For a full account of the experiment see Puget Sound Marine Station Publications, Vol. I.

of Sir Edward Forbes to divide the margins of the sea bottom into several belts, the uppermost of these is commonly known as the *shore belt* and reaches from the level of the usual high tide to the average of low tides which is about three feet above the mean low tide of the U. S. Navigation Charts. The reason for this lower limit not agreeing with the mean low tide lies in the fact that the usual low tide is considerably above mean low tide level so that animals living within about three feet from mean low tide are exposed out of water only for a few hours during a brief period once a month. A growth of Ulva which reaches up to this level covers the stones quite completely at such times so that the animals are not fully exposed.

Immediately below this is the Laminarian Belt which is characterized by broad leaved algae. The algae shelter animals from light and enemies. The lower limit of this belt is the lower limit of light for green algae. The Laminarian Belt extends from three feet above mean low tide to a depth of about sixty feet.

The belt below this is commonly known as the Coralline Belt because of the presence of Coralline Algae. For convenience it may be subdivided into the Coralline which reaches to 300 feet and the Subcoralline from 300 feet to about 600 feet. It is characterized by a very short daylight period and faint light at all times.

The advantages of the Puget Sound Marine Station locality for the study of physiological difference between animals from different depths lies in the fact that the abrupt shores make it possible to get animals from several different depths ranging from 0 feet to 540 feet (165 meters) within a few moments and submit them to experimental conditions within a short period.

II.—RESISTANCE TO HIGH TEMPERATURE.

The following selected results of comparison of the resistance of animals of the same species from different depths to fatal conditions will serve to illustrate the whole series of experiments.

TABLE I.

Showing the relative resistance of two Puget Sound commercial shrimps, the coonstripe (*Pandalus danae* Stimp.) and the deep coonstripe (*Pandalus stenolepis* Rath), from different depths to a temperature of 24° C. The animals were kept at this temperature in small dishes containing sea water surrounded by a large mass of water heated by an alcohol lamp.

Pandalus danae		Pandalus stenolepis	
Depth in Meters	Survival Time in Minutes	Depth in Meters	Survival Time in Minutes
4	34	....	.....
14-20	27	....	.....
40-60	21	40-110	11
60-100	13	100-140	8
100-156	12½	150-165	7

Marine animals, particularly fishes and crustacea, take on the color of the background present during development and those from considerable depth are pale in color and the shrimp have decidedly luminescent eyes. The relation of color to light and background has caused the shrimps from the different levels to be easily distinguished and also leads to the conclusion that they have lived at the level from which they were collected since an early juvenile condition, because it is only in the young that such changes can be brought about. The shrimps from the different levels were placed in the same dishes during the experiments so as to preclude the possibility of the different individuals, having been experimented upon under different conditions. The general results were confirmed by numerous tests at other temperatures.

It will be noted that the shrimps of each species from deeper water died in a shorter time. Likewise the shrimp which habitually lives at greatest depth dies much

quicker than those from the lesser depth. Crabs show similar relations. The data suggest that those that live in the dark are more sensitive than those from the light, which accords with the results with crabs from different depths.

III.—RESISTANCE TO FRESH WATER.

Marine animals do not generally survive for any length of time in fresh water or in water without their normal salt content. Taking for example one of the shrimps noted in the preceding table we find that loss of equilibrium follows in a few minutes after the animals are immersed in the fresh water.

Table II.

Showing the Survival of Marine Shrimps from different depths in Fresh Water.

Pandalus danae		Crangon munita Dana	
Depth in Meters	Survival Time in Minutes	Depth in Meters	Survival Time in Minutes
4-6	25	....	.....
12-20	23	15-20	54
30-50	13	35-75	24

Here again as in the case of temperature the shrimps from the shallower water survive longest. The same general results were obtained with mussels, barnacles, etc.

IV.—RESISTANCE TO ALKALINE AND ACID WATER.

The experiments with herring showed that the fishes are much influenced by the reaction of the water, i. e., whether it is acid or alkaline. Accordingly a series of experiments was run to determine the relative resistance of the animals from different depths to acidity and alkalinity.

Table III.

RESISTANCE TO ACID WATER.

(100 c. c. of tenth normal alkali required to neutralize one liter of sea water,—phenolphthalein indicator.)

Pandalus danae		Pandalus stenolepis	
Depth in M.	Time to loss of Equilibrium	Depth in M.	Time to loss of Equilibrium
4	10	50	13
20	23	40-60	14
100-150	81	170	18

Here the relative resistance of individuals from different depths is reversed; those from the deeper water lose their equilibrium later than those from the shallow water. Death follows after irregular intervals.

Table IV.

RESISTANCE TO ALKALINE WATER.

(41. c. c. of tenth normal acid to neutralize one liter,—methyl orange indicator.)

Pandalus danae		Pandalus stenolepis	
Depth in M.	Loss of equilibrium	Depth in M.	Loss of equilibrium
4	After 19 mins., 5 (all) on sides	10	After 67 mins., all dead
20	After 19 mins., 3 (of 5) on sides	180	After 92 mins., all alive

As in the case of the acid water the animals from deeper water are more resistant. There are some variations and irregularities, and while the experiments with acid and alkaline water were not extensive they indicate the reverse of the results with fresh water and high temperature.

V.—GENERAL DISCUSSION AND CONCLUSION.

The resistance to fresh water and to high temperature on the one hand and acid and alkaline water on the other being reversed, we conclude the physiological characters of the animals differ generally and that the differences are not purely adaptive adjustments. Fluctuations in temperature and salinity are greatest at the surface and thus animals at the surface might be expected to show greatest resistance to differences in these respects. On the other hand since fluctuations in degree of alkalinity are usually greatest in the region occupied by vegetation it would accordingly be expected that animals from the Laminarian Belt would be more resistant to alkaline conditions than those from deper water but such is not the case.

The experiments indicate that it is not safe to assume that individuals of a species have the same physiological constitution regardless of conditions or that the presence of a species coincident with a uniform condition of a given factor such as temperature does not indicate that temperature controls the distribution. The organism may be physiologically different.

In fresh water the presence of certain animals is often taken to indicate that conditions are suitable or detrimental to fishes, or that the water is or is not contaminated. Such conclusions must be made with due caution and variations in physiological characters of such index organisms must be fully investigated before their presence can be relied upon to indicate the conditions they are supposed to show.

THE INFLUENCE OF FASTING ON LOBSTERS*

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The most apparent effect exerted on living organisms by fasting is the loss of weight which they sustain. With the prolongation of the fast, which in the case of man has on many occasions exceeded a month and in the case of other animals even much longer periods, the diminution of the mass of the organism becomes so conspicuous as to point unmistakably to the serious organic changes wrought by the protracted abstinence from food. The emaciation of an individual is a positive indication that he is in a state of either chronic or acute starvation.

To the best of my knowledge of all animals, lobsters alone do not conform to the general rule. They offer no recognizable external signs of emaciation or loss of mass to warrant an observer in concluding that this or that lobster has been deprived of nourishment for any length of time. Indeed not only are the outward symptoms missing, which one so readily detects in a starving individual, but the weight of fasting lobsters changes so slightly that it can be found out only by very careful measurements.

I observed six lobsters in the course of a fast which lasted fifty-six days, during which time they were kept in thoroughly filtered sea water, and none looked different at the close of the ordeal from what they did at the beginning. They were weighed carefully every two weeks on a balance weighing accurately to one-hundredth of a gram, and the greatest loss observed was 1.89 per cent. of the initial weight in two weeks time, whereas the average loss for the eight weeks was only 2.89 per cent. It will be better appreciated how insignificant such a change is from a review of the actual weights, which

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* For a complete statement of the data the reader is referred to the author's article in the Journal of Biological Chemistry, Vol. 24, pp. 137-146, 1916.

at the beginning of the experiment was 167.5 grams and at the end 162.7 grams, or a difference of about one-sixth of an ounce.

This very slight change in weight is, however, deceptive, and behind an apparently immutable surface, as an investigation of the changes in the makeup of the lobsters reveals, far-reaching transformations are effected. To anticipate, a study of the chemical composition of the fasting lobsters proves that the exceptional position occupied by these animals in not conforming to the general rule of emaciation, is only skin deep and that the loss of substance which they suffer is as profound and fully as extensive as that sustained by any other organism.

It is a matter of common knowledge that every organism is composed of three kinds of material, water, organic and mineral matter. With respect to quantity, water is by far the most important of these three constituents. A normal lobster (including the shell) contains 67.3 per cent. of water. The remaining 32.7 per cent., or one third, is made up of 21 per cent. organic material and 11.7 per cent. mineral matter. It may therefore be said that, roughly, seven-tenths of the lobster is water, two-tenths is organic stuff, and one-tenth is a mixture of salts.

After fasting fifty-six days the composition of the lobsters changes radically. They now contain 78.2 per cent. of water, 10.8 per cent. of organic and 10.6 per cent. of mineral matter. Roughly speaking therefore, eight-tenths of the lobster is water and the organic and mineral portions represent each a tenth of the entire organism. A comparison of these figures shows at a glance that the content of fasting lobsters is greatly impoverished as regards its organic moiety, which involves all the edible and really nutritious elements, i. e., the glycogen, fat and proteins.

The difference in the relative composition (percentage) of the two kinds of lobsters is not sufficient, however, to fully picture the transformation effected by the fast, or to explain why the weight remains almost unmodified.

To gain a clear insight into these matters, we must compare the quantities of the various materials actually present in the lobsters before and after fasting.

The average weight of my lobsters was 167.3 grams, of which 112.7 grams was water and 35.2 and 19.5 grams was organic and mineral matter respectively. It may be observed further that the 35.2 grams of organic material are made up as follows: 0.27 gram of glycogen, 1.6 grams of fat, 17.3 grams of protein and 8.6 grams of what is commonly designated as "extractive." The remaining 7.4 grams, or a little over one-fifth of the entire organic matter, is probably chitin, the chief constituent of the shell.

The same lobsters, at the end of the fast, weighed on an average 162.6 grams. Of this 127.8 grams was water, 17.5 grams organic and 17.3 grams mineral matter. It is thus quite evident that one-half of the total organic matter has been lost, having been used up by the lobster in maintaining its existence while no other nourishment was available. It is also interesting to note that the organic material of the starved lobster contained no glycogen, only 0.1 gram of fat, 7.8 grams of protein and 2.6 grams of "extractives." There is thus 7 grams left over which probably represents the chitin. This quantity is very nearly the same which we found in the lobsters before they were subjected to the fast and we must conclude therefore that the shell has not been affected by the fast.

But the most significant fact disclosed by this study is the actual increase in the quantity of water from 112.7 to 127.8 grams. This absorption of water will help to elucidate the circumstance that in spite of the loss sustained by the organic portion of the body, the total weight of the lobsters remains almost stationary. Bearing this in mind, we may attempt to compute what the loss was at the end of fifty-six days of fasting. The loss observed in the change of body weight was only 2.73 per cent. Let us suppose, however, that no imbibition of water had taken place. With the knowledge gained from the study

of other fasting organisms we may assume that at this particular phase of starvation the quantity of water in the body would have diminished about a third. Starting with a quantity of 112.7 grams of water, this would have decreased to 75.1 grams at the end of fifty-six days of fasting, had there been no compensating absorption of water from the surrounding medium. The weight of the lobsters would therefore have been 109.8 grams, and the loss 34.4 per cent., instead of 2.73 per cent. The hard shell protecting the entire body of the lobster and forming a solid supporting structure, apparently prevents the cells of the soft tissues from shrinking as they ordinarily do under the influence of inanition* when the cell inclusions are being used up. This may explain the extraordinary extent of the imbibition of water by the tissues as their reserves are being gradually exhausted. The relative increase in the water content of the body which invariably occurs in inanition is unquestionably to reduce the concentration of the body juices. But the great absorption of water by the tissues of starving lobsters is the result primarily of mechanical factors, the tissues imbibing an excess of water in the manner of a sponge.

* Morgulis, S., Archiv für Entwicklungsmechnik d. Org. 32, p. 169, 1911.

THE NATURE OF THE SPINES IN CATFISHES

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Anyone who has handled catfishes, dead or alive, is probably painfully aware of the presence of heavy and sharp spines in the dorsal and pectoral fins. In the following paragraphs an attempt is made to explain briefly the morphologic nature of these spines; that is, how do they compare with the more flexible fin supports and with the spines of other fishes?

The fin is to be looked upon as an extension of the general integument of the body. In nature it is precisely as if the skin of the back of the hand were pinched and drawn away from the surface. The web of the fin thus constituted becomes useful as a balancer, propeller, or rudder by virtue of its flexibility and consequent freedom of movement and at the same time has the possibility of a certain amount of rigidity. All these characteristics are imparted to the fin by its inner supports called fin-rays, to which group of structures the fin-spines belong.

The nature of any type of fin-spine is better appreciated after a review of the more common and more primitive fin supports, namely, the soft rays. This kind of ray is most numerous in fishes and because of its soft or flexible state it receives its designation. Its rôle in the fin is that of a skeletal support to the fin-web only. The origin and homology of the soft rays have been traced by Goodrich[1], Harrison[2] and others, and may, therefore, be omitted here. Much more desirable is a knowledge of the simple structure of a soft ray. In this connection there are two features to be noted. First, rays of this type are always dichotomously branched. The base of the ray is heavy and solid, but soon divides into

1. Goodrich, E. S. Jour. Mic. Science, vol. 47, 1903.
2. Harrison, R. G. Arch. f. Mik. Anat, vol. 42, 1893.

two parts, each of which divides into two and so on to the periphery of the fin. Because of this branching the ray becomes fan-shaped, supporting a much greater extent of the web at its free edge than at its base, Fig. 1. Second, each division of the ray is transversely segmented, a state which makes for flexibility as well as indicating its morphologic nature.

In what may, for convenience, be termed the "higher" or more modified bony fishes—strong and sharp spines may be present in all fins excepting the caudal. The Yellow Perch serves as a good example. The first dorsal of this species is supported entirely by spines. They are heavy at the base and with an even surface regularly taper to a sharp point at the margin of the fin-web, Fig. 2. They are without either transverse segments or branches. Spines of this type may be said to result from a suppression of branching and segmentation during development. Each spine, therefore, as an entity is an exact match for a soft ray. When the segmentation persists without the branching there results what has been termed a simple ray, Fig. 3. So far as definitive structures are concerned the simple ray occupies an intermediate position between soft rays and spines.

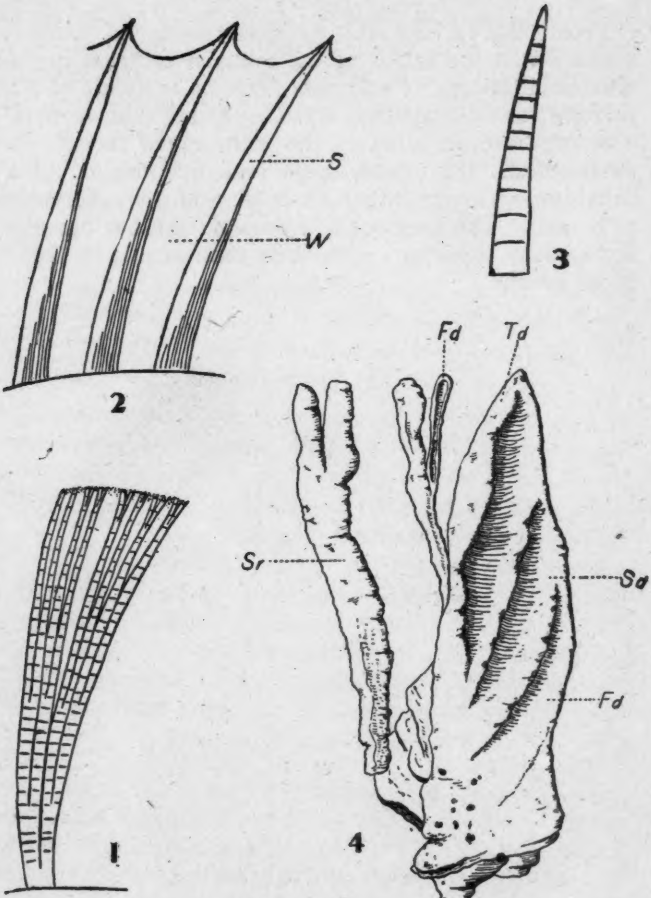
The presence of the catfishes among the groups commonly designated as soft-rayed fishes leads one to wonder at what appears to constitute an exception to the rule of the absence of fin-spines among these forms. There is no doubt about the rigidity, sharpness and efficiency of catfish-spines as organs of defence. They appeal to one as true functional spines whatever may be their nature in a structural way.

Observations upon the microscopic structure and development of catfish spines leads one to the conclusion that while they are strong and sharp spine-like structures in function their nature in a morphologic way is not such as to be considered widely different from that of soft rays. It has been noted above that the spines of the more highly modified fishes are regular with regard to surface. Quite the reverse of this state obtains

in the spines of catfishes. While still covered by skin they may appear smooth enough, but after the soft tissues are removed the surface is found broken by deep and more or less longitudinal furrows with corresponding intermediate ridges, Fig. 4. These ridges are reminiscent of the ankylosis of dichotomous divisions of soft rays. The spine as a whole represents a single soft ray. Instead of a derivation through the suppression of branches and the early co-ossification of segments, the spines of catfishes ossify and become rigid after the formation of the dichotomous branches has taken place. This is clearly shown by a study of both the surface of the spine and microscopical preparations.

As a rule the anterior branch of the first soft ray in a fin is the shortest one, the succeding divisions becoming progressively longer according to the curvature of the edge of the fin-web. These relations are obvious in the elements of the spines of catfishes as shown in Fig. 4. The first ridge (fd.) on the anterior side of the spine represents the first division of the ray. It extends diagonally towards the anterior margin and comes to an end somewhat before the middle of the spine is reached. The second (sd.) division is similar in appearance and course, but does not end until the distal half of the spine is reached. The third (td.) is the longest of the spine elements and forms the point. The fourth (fd.) although not so pronounced as the other divisions is incorporated with the spine to about the middle of its extent at which level it fails to co-ossify with others and becomes an independent division in the fin-web near the margin of which it divides. The free portion of this division is in every respect like that of soft rays. In the proximal portion of the spine, particularly of very young specimens there are numerous openings extending into the cavity. These represent the last vestiges of the spaces between segments. As the fish matures new bony tissue is deposited in the longitudinal grooves which become less and less conspicuous with age.

From observations such as those mentioned above it appears that the spines of the common catfishes represent modifications of soft rays through ankylosis of the segments and dichotomous divisions rather than suppression of those parts as in the spiny-rayed forms. In other words, the catfish spine is a modification of a definitive soft ray rather than that of its embryonic rudiments. The presence of spines in catfishes becomes harmonious, therefore, with their rank among the soft-rayed groups.



EXPLANATION OF FIGURES.

Fig. 1. Diagram of a soft ray.

Fig. 2. Diagram of a fin-spine. S., spine; W., web of fin.

Fig. 3. Diagram of a simple ray. It possesses transverse segments but no branches.

Fig. 4. Diagram of a wax model of the spine of the common bullhead, *Ameiurus nebulosus*. Fd., first division of ray; Sd., Td., Fd., second to fourth divisions respectively. Sr., first soft ray of fin.